**FIRST PAGE OF THE ARTICLE**

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

TITLE: Age Related Differences on Cognitive Overload in an Audio-Visual Memory Task

AUTHOR(S) First name Family name Institution, Country

1: Jennifer Murray Glasgow Caledonian University, Scotland, UK

2: Mary Thomson Glasgow Caledonian University, Scotland, UK

ABSTRACT (max: 200 words; French and English)

English:

The present study aimed to provide evidence outlining whether the type of stimuli used in teaching would provoke differing levels of recall across three different academic age groups. 121 participants, aged 11-25 years, were given a language based memory task in the form of a wordlist consisting of 15 concrete and 15 abstract words, presented either visually, acoustically, or a combination of both audio and visual presentation. The study found that the presence of cognitive overload was greater in the older academic age participants than in the younger groups and that as academic experience increased, the visual presentation of the target stimuli produced greater levels of recall than was the case with acoustic and audio-visual presentation. Overall the findings indicate that cognitive overload increases with age, as the younger age groups were found to have significantly higher levels of word recall in the audio-visual condition than the older groups.

French:

La présente étude visait à fournir des preuves indiquant que le type de stimuli utilisés dans l'enseignement provoquerait des niveaux différents de rappeler à travers trois différents groupes d'âge scolaire. 121 participants, âgés de 11-25 ans, ont eu une tâche de mémoire linguistique en fonction sous la forme d'un dictionnaire composé de 15 en béton et 15 mots abstraits, présenté soit visuellement, acoustiquement, ou une combinaison des deux audio et visuels de présentation. L'étude a révélé que la présence de surcharge cognitive était plus élevée chez les participants plus âgés universitaires que dans les groupes plus jeunes et que l'expérience universitaire a augmenté, la présentation visuelle des stimuli cibles produites niveaux plus élevés de rappeler que ce fut le cas acoustique et audio- présentation visuelle. Globalement, les résultats indiquent que les augmentations de surcharge cognitive avec l'âge, comme les groupes d'âge plus jeunes ont été trouvés à des niveaux significativement plus élevés de rappel de mots dans la condition audio-visuelle que les groupes plus âgés.

FIRST PAGE FOOTNOTE (if any: financial support, acknowledgments……)

RUNNIG HEAD (max: 50 characters)

Age Differences in Cognitive Overload

KEY WORDS (max: 5, alphabetic order)

Ageing, Audio-Visual Memory, Cognitive Overload, Memory, Recall

(for Assistant Editor only)Received: Revision received:

**PERSONAL DETAILS (for each author)**

First name, Family name, (Institution: Department, University, …), complete address, professional E-mail, web site of Institution (if any)

Jennifer, Murray, (Department of Psychology, Glasgow Caledonian University), 70 Cowcaddens Road, Glasgow, G4 0PP, Scotland, UK, jennifer.murray@gcu.ac.uk

Mary Thomson, (Department of Psychology, Glasgow Caledonian University), 70 Cowcaddens Road, Glasgow, G4 0PP, Scotland, UK, m.thomson@gcu.ac.uk

­

# Current themes of research:

Jennifer Murray’s current research interests focus primarily on examining judgemental bias in clinical judgements of violence risk assessment. She is also interested in the changes in memory across the lifespan, having previous research experience investigating the impact of glucose on prospective memory and eyewitness’ memory across older and younger adults.

Mary Thomson’s research focus is on all aspects of judgment and decision making. She has published in a wide variety of books and journals, including The Journal of Behavioral Decision Making, Risk Analysis, the International Journal of Forecasting, The European Journal of Operational Research and Decision Support Systems.

Most relevant publications in the field of Psychology of Education (max: 5)

Murray, J. & Thomson, M. E. (2008).  The Effects of Academic Experience on the Presence of Cognitive Overload in an Audio-Visual Memory Task.  *Proceedings of the BPS Cognitive Section Conference*, p.77.

Running Head: AGE DIFFERENCES IN COGNITIVE OVERLOAD

Title: Age Related Differences on Cognitive Overload in an Audio-Visual Memory Task

Jennifer Murray1\*, Mary E. Thomson1

1. Department of Psychology, Glasgow Caledonian University, 70 Cowcaddens

Road, Glasgow, G4 0PP

\*Requests for reprints should be addressed to Jennifer Murray, Department of Psychology, Glasgow Caledonian University, 70 Cowcaddens Road, Glasgow, G4 0PP, Scotland, UK (e-mail: [jennifer.murray@gcal.ac.uk](mailto:jennifer.murray@gcal.ac.uk)).Abstract

The present study aimed to provide evidence outlining whether the type of stimuli used in teaching would provoke differing levels of recall across three different academic age groups. 121 participants, aged 11-25 years, were given a language based memory task in the form of a wordlist consisting of 15 concrete and 15 abstract words, presented either visually, acoustically, or a combination of both audio and visual presentation. The study found that the presence of cognitive overload was greater in the older academic age participants than in the younger groups and that as academic experience increased, the visual presentation of the target stimuli produced greater levels of recall than was the case with acoustic and audio-visual presentation. Overall the findings indicate that cognitive overload increases with age, as the younger age groups were found to have significantly higher levels of word recall in the audio-visual condition than the older groups.

Keywords: cognitive overload, audio-visual memory, recall, ageing.

Age Related Differences on Cognitive Overload in an Audio-Visual Memory Task

Introduction

Within the educational system, research concerning different teaching/learning methodologies is considered important, not only from a practical point of view (Smith, Higgins, Wall, & Miller, 2005), but also from a financial standpoint (Wall, Higgins, & Smith, 2005). For example, the introduction of expensive interactive whiteboards into schools is thought to aid the initial learning, concentration and understanding of younger pupils (Smith *et al*., 2005), but with no long term or academic testing methods in place within the participating academic institutions the proposed long term benefits are as yet unknown, if indeed present. In modern education, learning materials are typically presented in simultaneously spoken and written formats. It is thought that this method of information presentation will provide the learner with optimal opportunities to achieve the transmission of information into long term memory, thus aiding their learning capabilities (Saada-Robert, 1999).

However, research into optimal learning conditions has provided conflicting data concerning which method for teaching is best: multiple stimuli or single stimulus presentation. For example, Tindall-Ford, Chandler, and Sweller (1997) found that superior learning was made possible through a ‘dual-mode’ presentation of information. These researchers presented participants with either an auditory representation of text in conjunction with associated visual diagrams (dual-mode presentation) or with a visual representation of text in conjunction with associated visual diagrams (mono-mode presentation). They found that with the dual-mode presentation, superior learning (measured via recall) was demonstrated, and suggested that this effect was due to an “effective expansion of working memory” (Tindall-Ford *et al*., 1997, pp.257). Moreno and Mayer (2001), on the other hand, explored the multi-stimuli learning approach in a similar fashion to Tindall-Ford *et al*. (1997), but conflicting results were evident. Unlike Tindall-Ford *et al.* (1997), Moreno and Mayer (2001) found that participants exposed to multiple stimuli (the inclusion of acoustic stimuli to a visual stimulus, in this case) performed significantly worse than those who were exposed to purely a visual stimulus. Moreno and Mayer (2001) suggested that rather than expand working memory, multiple stimuli presented in unison can overload working memory, thus preventing the optimal transmission of information into long term memory and therefore hindering learning. Research such as this is clearly important in terms of the teaching methodologies used within educational establishments, but is also of interest with regards to the recent upsurge of computer-based teaching software (Chen, Lui, & Chang, 2006).

With the use of computer and internet-based learning increasing in recent years, it is important for the computer-based learning software to provide the best possible opportunity for learning with regards to the presentation of information. Chen *et al.* (2006) have suggested that no fixed learning pathway could be appropriate for all users of a computer-based learning program, proposing that personalised systems may offer a solution. For example, within a personalised system, the user is able to alter variables and choose the sequencing of lessons to suit their own preferences. Whilst this may appear an attractive solution to the diminished capacity for learning associated with computer-based learning, the personalisation of the programs often do not consider the associated difficulty levels of the users selected course pathway in relation to their cognitive abilities, largely due to the difficulty in ascertaining such information out-with scaled testing methods. In addition, Papinikolaou, Grigoriadou, Magoulas and Kornilakis (2002) suggested that while computer-based learning programs can be useful, in that users are able to learn at their own pace and in their own time, they may also be detrimental. These researchers found that it was not necessarily the change in the sequencing of lessons that hindered the users learning, but rather the addition by the user of multiple stimuli during the lesson (i.e., video streaming, textual information, acoustic stimuli, and colour variation), leading to the user becoming disoriented and/or over-stimulated, resulting in lower levels of learning.

Teaching strategies utilised within educational establishments must also consider factors concerning age-related cognitive functioning. For example, Saada-Robert (1999) conducted a case study involving 7-8 year olds, attending the same school and class lessons, and found that the younger participants among the sample were more susceptible to spelling mistakes, especially when presented with more than one educational task at a time. Saada-Robert (1999) suggested that this difference in cognitive ability, with regards to erroneous spelling, may be associated with age and cognitive development. For example, for the older participants within the sample, the utilisation of previously planned knowledge in writing tasks was more prominent than in the younger participants, demonstrating the ability within the older age group to manage their cognitive resources without experiencing detrimental over-load. Similarly, Lechuga, Moreno, Pelegrina, Gomez-Ariza, and Bajo (2006), found that younger children (mean age 8 years) were less able to intentionally suppress information than older children (mean age 12 years) and that adults and were more likely to err by involving irrelevant information, in the form of additional information. This failure to inhibit irrelevant information suggests developmental changes in the efficiency with which memory capabilities are used, in terms of suppression abilities between the ages of 8-12 years. The researchers did not find, however, any age-related difference between working memory load capacity.

Within the topic of learning methods, it is important to distinguish the processes within memory being investigated. The majority of research (the present study included) relies upon memory tasks to assess the levels of information that have been transmitted into long term memory through working memory (Saada-Robert, 1999). The way in which information is transmitted into memory is also of importance for the purpose of multiple-stimuli learning (Hoye, Dickenson, Banos, & Gierock, 2000), as different types of stimuli are transmitted through different pathways into long term memory. It is thought that while visual perception ascribes to specific, consistent mechanisms (Diehl, Lotto, & Holt, 2003), with stimuli thought to be represented as mental images, acoustic perception is generally considered as more complex with regards to encoding into long term memory, as no specific pathway is ascribed. It is generally accepted that acoustic-verbal stimulus perception is largely based within visual perception (Fowler, 1986). For example, Fowler (1986) found that the lip movements and gestures of a talker significantly correlated with the listener’s perceptual judgement, thus indicating that the acoustic signal is structured by, and therefore encoded in association with, a visual stimulus. It is further argued that due to the dual pathway through which acoustic stimuli are encoded into memory, learnersmay become cognitively over-loaded when an acoustic stimulus is presented in unison with, for example, a visual stimulus (Saada-Robert, 1999). This effect upon the transmission of information into long term memory, when multiple stimuli are presented, may to an extent explain for the aforementioned findings of Moreno and Mayer (2001), i.e., multiple stimuli leading to lower levels of learning.

It must also be understood that as information is being transmitted through working memory into long-term memory, tasks aiming to assess the effects of multiple stimuli on participant learning abilities are thus not primarily studying learning, but rather are investigating memory and recall (Craik & Lockhart, 1972) in order to assess learning.

Based upon Sweller’s (1988) original Cognitive Load Theory (that is, too many different forms of presented stimuli leading to the inability to concentrate and thus the processing of redundant material, creating excessive working memory load, thus inhibiting the individual’s overall learning capacity), Kalyuga, Chandler, and Sweller (2004) hypothesised that if visual and acoustic stimuli were presented in unison, learning and understanding of the given material would be impeded. Participants were presented with textual information in one of three forms: visually, acoustically, or both visually and acoustically in unison. It was indeed found that the multiple stimuli presentation achieved the lowest levels of retention, and therefore learning, of the three presentation methods, with the acoustic presentation method meriting the highest levels of retention. This finding of acoustic superiority in Kalyuga *et al.’s* (2004) research is in contrast to the previously discussed research by Saada-Robert (1999), which outlines acoustic stimuli to be a poor presentation method for learning due to the complexity of the pathways through which it is transmitted into long term memory. Kalyuga *et al.’s* (2004) experimental procedure was replicated within research conducted by Conway and Christiansen (2005). These researchers’ findings paralleled those of Kalyuga *et al.* (2004), with multiple stimuli presentation once again providing the lowest levels of the three methods of presentation, thus providing further evidence for the existence of cognitive overload.

As few researchers within the field of cognitive overload have explicitly investigated the effects of age and/or academic experience on levels of cognitive overload, the present research aimed to investigate whether or not the age of an individual would have an effect on the presence and/or levels of cognitive overload found within an audio-visual memory task.

Although it is generally accepted within the field of memory research that words being concrete or abstract do not have any significant effects between auditory, visual or audio-visual memory and recall abilities (Hirsh & Watson, 1996), the present research chose to include equal numbers of concrete and abstract words within the wordlist in order to nullify any possible concrete-bias effects, relating to the number of and demographics of the recalled words. Leech, Rayson and Wilson’s (2001) report of frequency per million words, both spoken and written, in the English language was further utilised to regulate consistency in word recognition within the wordlist. The words used within the present study may therefore be considered to be relatively recognisable across the three age groups selected, and therefore may be considered as suitable with regards to age related comparisons of recall ability.

The present research considered the consistency in the length of time gaps between words presented acoustically of utmost importance. Hirsh and Watson (1996) stated that within acoustic memory tasks, the rhythm of the test sequence, thus the interval timing between words (or other acoustic stimuli), must be kept constant in order to prevent biases in memory. Furthermore, based upon Hirsh and Watson’s (1996) research, the present study recorded the acoustic word sequence, controlling for pitch and tone, in order to prevent memory biases due to the complexity of the differing areas used in the brain for auditory encoding (Hirsh & Watson, 1996) affecting the results of the study.

Recording the acoustic stimuli further protected the present research from biases relating to lip movements and other gestures affecting results (Fowler, 1986; Liberman, 1996). Liberman (1996) argued that lip movements and the gestures used by a speaker act to structure the associated acoustic signal, thus producing a medium through which the listener could encode the message into memory. Thus, by presenting a recorded acoustic stimulus, consistency with regards to the way in which the acoustic signal is encoded between the presentation methods was achieved.

As the present study aimed to primarily test differences in retrieval and retention pending on varying stimuli presentation methods, it was considered that working memory capacity is not restricted by age (Lechuga *et al*., 2006). However, the consideration of age-related resource management, with regards to working memory abilities as previously described by Saada-Roberts (1999) and Lechuga *et al*. (2006), such as spelling errors and the addition of irrelevant words in a test answer, respectively, must be taken into account. In order to account for age-related erroneous spelling, the present study decided to overlook minor spelling errors within the responses given by participants (for example ‘hart’ rather than ‘heart’).

Based upon the afore-mentioned research, the following hypotheses were formulated: H1 – Cognitive overload will be present within the older age participants, but not within the younger age groups; H2 – As academic experience increases, the visual presentation method will aid recall more so than the acoustic presentation method; H3– As age increases, the visual presentation method will aid recall more so than the audio-visual presentation method; H4 – The acoustic presentation of information will achieve the lowest levels of recall of the three proposed conditions across all three participant age groups.

Methodology

*Design*

A 3x3 independent groups’ design was adopted, with participants being randomly assigned to one of three experimental conditions: visual presentation, acoustic presentation, or simultaneous audio-visual presentation. Participants belonged to one of three age groups: younger age, mid age, or older age. The independent variables were participant age group and the condition of presentation that participants were exposed to. The dependant variable was the number of words correctly recalled from the word list. Post-hoc power analysis (using G\*Power 3; Faul, Erdfelder, Lang, & Buchner, 2007) measuring for large effect size (0.4, following Cohen’s conventions), with α set at 0.05 (following the norm) indicated 1-β to be 0.95. It was therefore concluded that the study was adequately powered.

*Participants*

121 participants participated in the current research. Forty participants belonged to the older-age groups, and were recruited from a sample of 3rd/4th year university students (age range 20-25 years; mean age 21 years; 23 males, 17 females). Thirty-four mid-age participants were recruited from a sample of 5th/6th year secondary school pupils (age range 15-17 years; mean 16 years; 9 males, 25 females). Forty-seven younger-age participants were recruited from a sample of 1st year secondary school pupils (age range 11-12 years; mean 11.8 years; 18 males, 29 females). All participants were recruited from Scottish educational establishments, and were either students or pupils studying within these establishments. All participants indicated English to be their native language. Furthermore, since only pupils with at least basic vocabularies were permitted by their teachers to carry out the task and the students were attending university, the participants were deemed to be suitable to participate in the current research.

*Apparatus*

Pens, a stopwatch, parental consent forms for the younger- and mid-age participants, participant consent forms, instruction sheets and answer grids were used. The sound editing programme *Wavepad* was used to ensure two second intervals between words for the acoustic condition and to remove static noise and equalise volume and pitch, and a *Sony* mp3-speaker system was used in the audio and audio-visual presentations. The word list used was composed specifically for the purposes of the current research. As the stimuli were being presented through three different means (visually, acoustically or simultaneous audio-visual presentation) and as there were three distinct age groups being tested, it was deemed necessary to compose a wordlist which was not only recognisable across all three of the age groups, but that was also equally recognisable across the different types of presentation methods. The word list used was therefore drawn from Paivio, Yuille, and Madigan’s (1968) highly concrete and highly abstract rated word list (15 concrete; 15 abstract; see Appendix A for the word list), thus providing a word list which contained easily words that were simple to visualise and comprehend across the age groups. In order to prevent bias in terms of recognisability in either the acoustic or the visual presentation, the word list was further regulated through Leech *et al.’s* (2001) report of frequency per million words, both spoken and written, in the English language (see Appendix B for the frequency breakdown). Thus, the word list used in the present research was composed in order to prevent recognisability bias across the three tested age groups and across the three presentation methods used in the research. In order to test the reliability of the wordlist used in the current research, Cronbach’s alpha was calculated, resulting in a value of 0.51. While this falls short of the generally accepted 0.6-0.7 cut-off, for the purposes of the aims of present research (i.e., to investigate the *total* number of words recalled by participants, regardless of meaning or construct), factor analysing the wordlist into sub-scales was deemed irrelevant. This may, however, be of interest to future researchers.

*Procedure*

Testing was conducted in the participant’s regular classroom groups, with a total of nine classes being tested overall. The participants were unaware of there being multiple conditions within the experiment until a debriefing as to the overall purpose and aim of the experiment upon task completion. Participants were exposed to only one of the three methods of presentation. Thirty words were presented either visually, acoustically (pre-recorded), or simultaneously for 1½ minutes, after which a three minute interval was given during which participants were asked to sit quietly and try to remember as many words as possible. After the break, five minutes were given for participants to write as many recalled words as possible from the word list on the answer grid provided.

Results

A 3x3 unrelated analysis of variance was conducted in order to test the hypotheses that as age increases, the visual presentation method will result in higher levels of recall than the acoustic (H2) and audio-visual (H3) presentation methods, and to test the hypothesis that the acoustic method of information presentation will result in the lowest levels of recall (H4). The dependant variable was the number of correct words recalled by participants and the independent variables were the three age groups tested (younger-, mid-, and older- aged), and the method of information presentation, measured over three levels (visual presentation, acoustic presentation, and audio-visual presentation). Table 1 displays the mean number of words correctly recalled by the participants, across the nine resulting groups.

*Table 1 about here*

A significant main effect of presentation method was found (F=17.58, df=2, 112, p<0.001), suggesting that the number of correctly recalled words differed significantly across the three presentation methods investigated in the present research. As shown in Table 1, the acoustic method of presentation resulted in the lowest number of recalled words (mean 8.5) in comparison to the relatively even number of recalled words found in the visual (mean 12.74) and audio-visual (mean 12) presentation methods. This finding suggests that of the three presentation methods investigated in the current research, the acoustic method of presentation is poorest for encouraging recall, therefore supporting H4. There was no significant main effect found for age group (F=0.339, df=2, 112, p=0.713), suggesting that the number of recalled words did not differ across the three age groups tested.

The two-way interaction between age and presentation method was found to be significant (F=4.275, df=4, 112, p=0.003), suggesting that the number of correctly recalled words was not identical across the three presentation methods and for each of the three age groups. As illustrated in Figure 1, the visual presentation of information produced higher levels of recall than in the other two presentation methods only in the findings for the mid- and older- age participants: audio-visual presentation produced the highest levels of recall in the younger age participants. Thus H2 and H3 were supported, with greater levels of recall being higher in the visual condition than in the acoustic and audio-visual conditions in the mid- and older- age groups.

*Figure 1 around here*

Further illustrated by Figure 1, the acoustic method of presentation resulted in the lowest levels of recalled words in comparison to the other two methods of presentation, across all three academic groups, thus supporting H4. As illustrated in Figure 1, the audio-visual presentation method produces steadily decreasing levels of recall over the three academic groups, while the single stimulus presentation methods increase and level off with increasing age. From these findings it can be ascertained that H1: cognitive overload will be present within the older age participants, but not within the younger age groups, was supported.

Discussion

The theory of cognitive overload suggests that when multiple stimuli are presented in unison, the learning and understanding of the given material is impeded. The present research investigated this theory, while considering the apparent age-related inconsistencies across non-related research. For example, the presence of cognitive overload in adult samples (e.g., Kalyuga *et al*., 2004) but not within child samples (Smith *et al*., 2005). It was therefore hypothesised that of the three age groups studied, cognitive overload would be found within the older group but not the younger age groups. It was further hypothesised that the visual method of information presentation would produce higher levels of recall than the acoustic presentation method, and the audio-visual presentation method, and that the acoustic method of presentation would produce the poorest levels of recall overall.

These hypotheses were tested by means of a 3x3 ANOVA. Significant differences in the numbers of words recalled across presentation methods, but not across the different age groups, were established, with a significant interaction effect between the presentation methods and the age groups tested being found. As shown in Figure 1, the number of words recalled in the audio-visual presentation method steadily decrease as the age of the participant groups increased, while the single stimuli presentation methods were seen to rise and level off. Based upon these findings, it can be seen that cognitive overload is indeed more highly prevalent in the older age participants than in the younger groups. In addition, the acoustic method of presenting learning information produced the lowest levels of recall in each of the three academic groups. This finding suggests that the use of acoustic presentation alone ought to be avoided, where possible, when teaching within educational establishments.

The findings of the present research highlight important implications for the way in which information is presented within ‘older age’ learning environments, such as universities. That is, if the use of multiple stimuli is commonly used within teaching, and the use of multiple stimuli as a presentation method in teaching leads to poorer levels of recall (thus retention) from memory than through the use of visual presentation alone, it may then be assumed that optimal learning will not be met. As previously discussed, the optimal learning environment is not only sought in terms of practical importance (e.g. teaching hours; students gaining the best possible chance of optimal learning) as outlined by Smith *et al.* (2005), but also in terms of financial worth (Wall *et al.*, 2005). Thus, if the optimal learning conditions are not met, higher long term costs will be incurred by an institution, ultimately leaving the institution with non-optimal performance rates and with a consequently lower resulting cash budget with which to improve upon learning conditions.

With regards to university teaching methodologies, it is the use of audio-visual methods which has become the preferred method by lecturers (Ahmed, 1998). That is, the use of Powerpoint slide presentations to facilitate lecture materials in place of using acetates or indeed no visual materials, has become commonplace within the university teaching environment. In relation to the current findings, one may assume that this method may not be ideal, as with increasing age, multi-modal stimulus presentation leads to poorer retention and recall. However, one must also consider the somewhat abstract nature of the task used in the present research: a wordlist presented under experimental circumstances can certainly provide information at a ‘base level’, but it cannot be applied directly to the classroom environment. Within the real world learning environment, a number of factors may further influence retention and recall of information, e.g., attention, social and peer group expectations/influences, and communication and participation during class time.

Ryan, Carlton, and Ali (1999) conducted a qualitative investigation into student perceptions of classroom (multi-modal) versus electronic (visual) methods of course delivery. The authors found that while both approaches gained positive and negative commentary, it was the interaction, participation and communication aspects which were rated higher in the classroom approach. In relation to multi-modal teaching methods (such as using a blend of web-based and classroom based teaching, or indeed the use of multiple stimuli to present course materials), the key to an improved university learning environment may, therefore, be to increase student participation and interaction.

One way in which to increase student participation in traditional ‘audio-visual’ method lectures is to incorporate a student electronic voting system. These systems can be incorporated into normal lectures and tutorials with the aim of promoting student engagement in classes (Draper & Brown, 2004). To illustrate the nature of these voting systems for the reader, within a class group each student is provided with a handset on which different buttons exist to represent different voting options. During the class, the lecturer may ask a question specific to the topic being covered and students will be provided with a number of options for the answer (as in a multiple-choice methodology) and will be asked to select their option on their handset. The responses from all students are then collated and the lecturer can then, for example, choose to provide the correct option to students or raise a discussion about why students chose particular responses. Draper and Brown (2004) describe the impact of using an electronic voting system over two years across eight university departments. With regard to the summative findings (responses by students to the question ‘How useful do you think the handsets are?’), the majority of students were reported to have rated the use of the voting system as either useful or very useful. When asked to rate the benefit versus disadvantage of using the system in lectures, again, the majority of students responded in a positive way, with the most popular response being that the ‘benefits outweigh any disadvantages’ followed by ‘definitely benefitted’. The authors proposed that the use of this type of system may promote interaction overall and by students who would not necessarily ask questions in the first place, and that it may therefore promote discussion on the topic being covered, thus moving the mode of presentation away from simply audio-visual to interactive and communicative. Draper and Brown (2004) do, however, emphasis that the technology should only be used when benefitting education, rather than for its own sake.

With the relatively low participant numbers used within the present study, a larger scale repetition of the present research would be beneficial. This would allow the extent to which differences in the presence of cognitive overload exist between different academic age groups to be determined to a greater extent. From this information, possible improvements that could be made within educational establishments, with regards to optimal learning conditions, could be more adequately assessed and suggested.

No apparent difficulties in recognising words arose in the process of testing. This suggested that the wordlist constructed for the purposes of the present research, which was composed of words which contained equal numbers of similarly rated concrete and abstract words, selected from Paivio *et al.’s* (1968) original word list, with word commonality being regulated through Leech *et al.’s* (2001) record of the frequency lists of spoken and written words in the English language, was successful.

With any methodology utilizing groups of participants, considerations of attention and distraction must be acknowledged. Within any group setting, distraction exists (Jiang & Leung, 2005). Jiang and Leung (2005) suggest that distraction leads to diminished attention to a stimulus, in turn affecting the learning and therefore recall of participants.In order to control for distraction, to some extent, the present research considered conducting the experiment with each participant being tested in isolation. However, based on the aim of maintaining the ‘classroom’ experience within testing, this method was not utilised. It may be determined, however, that within working memory formats of experimentation, attention is of the utmost importance, and is decreased in group settings (Jiang & Leung, 2005), thus promoting the methodology of testing participants in isolation. While it is possible that this may decrease ecological validity, isolation may be a key factor in maintaining the participant’s attention on the stimulus being presented.

It must be considered that due to the differences within each of the classrooms (the present study utilised field research) there is no guarantee that the nine groups of participants experienced the information presented in the same way, and with equal quality. The incongruence between room size and layout may have affected results to some extent; due to the different layouts of each room, the quality of the acoustic and visual stimuli cannot be guaranteed across the nine participant groups tested. Future research should consider standardising the experiment room. For the purposes of future research, and taking the discussed limitations of the present research into account, the experiments could be conducted within a single, standardised room, with a standardised evenly spaced seating arrangement. While this would decrease the levels of authenticity of the ‘classroom’ experience achieved in the present research, ultimately standardisation of surroundings would lead to a higher level of comparable data between groups.

In addition, as no measures of vocabulary or verbal ability were administered in the current research, no definite information can be given on this. As such, the current research cannot rule out the possible influence of verbal ability on the findings. However, all of the participants indicated that their native language was English, and the students involved in the older participant group had the appropriate level of verbal ability required to gain entry into university in the first place and the participants involved in the two younger pupil groups were provided by the school with the understanding that they had the appropriate level of verbal ability (determined through pre-testing discussions with the individual class teachers). In addition, the word list was created in order to contain only words which were highly recognisable in both spoken and written English and that were no longer than two syllables long and minor spelling errors within the responses given by participants were overlooked, as discussed earlier. Based on these considerations, the participants’ verbal ability was deemed sufficient for taking part in the research despite no formal measure of verbal ability being utilised, and the wordlist was considered suitably recognisable across all three of the participant age groups tested with minor issues, such as erroneous spelling, being taken into consideration and accounted for when analysing the data. However, in order to rule verbal ability out as a possible influencing factor, future research should consider implementing a measure of verbal ability.

Another important limitation of the present research is the fact that no measure of intelligence was taken. In particular, the influence of crystallised intelligence (Cattell, 1963) may be of importance when determining age related differences in memory. The use of crystallised intelligence is present in tasks which involve previously acquired skills (e.g., the reading and recognition required to recall words such as those used in the present research). In addition, crystallised intelligence is directly affected by the specific learning experiences that an individual has had. It is this latter aspect in particular that is of importance when considering age related differences in memory and recall; i.e., as older participants have had more experience academically, in for example reading and writing, they will logically have an improved level of crystallised memory in this area than those who are younger. Thus, as individual differences in intelligence may have been an important factor affecting the overall recognition, retention and recall of words from memory, future research of this nature should include a measure of intelligence in addition to the memory task of interest.

The overall findings of the present study indicate that the presence of cognitive overload is indeed varied across different academic age groups. From the findings, it can be determined that the level of academic experience gained by an individual may alter the way in which an individual responds to varying types of stimuli. With reference to the findings of the present study, it can be seen that as academic experience increases, the ability to recall information presented by simultaneous visual and acoustic presentation declines. The findings of the present research therefore serve to highlight the need for greater levels of research into the optimal information presentation methods, as suited across different academic age groups.References

Ahmed, C. (1998). *Powerpoint versus Traditional Overheads. Which is More Effective in Learning?* Paper presented at South Dakota Association for Health, Physical Education and Recreation, Sioux Falls, South Dakota, November 1998.

Cattell, R. B. (1963). Theory of fluid and crystallized intelligence: A critical experiment. *Journal of Educational Psychology*, **54**, 1-22.

Chen, C. M., Lui, C. Y., & Chang, M. H., (2006). Personalized curriculum sequencing utilising modified item response theory for web-based instruction. *Expert Systems with Applications*, **30(2)**, 378-396.

Conway, C. M., & Christianson, M. H. (2005). Modality constrained statistical learning of tactile, visual, and auditory sequences. *Journal of Experimental Psychology: Learning, Memory and Cognition*, **31(1)**, 24-39.

Craik, F. I. M., & Lockhart, R. S. (1972). Levels of processing: A framework for working memory research. *Journal of Verbal Learning and Verbal Behaviour*, **11**, 67-84.

Draper, S. W., & Brown, M. I. (2004). Increasing interactivity in lectures using an electronic voting system. *Journal of Computer Assisted Learning*, **20**, 81-94.

Diehl, R. L., Lotto, A. J., & Holt, L. L. (2003). Speech perception.  *Annual Review of Psychology*, **55**, 149-179.

Faul, F., Erdfelder, E., Lang, A.-G., & Buchner, A. (2007). G\*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods*, **39(2)**, 175-191.

Fowler, C. A. (1986). An event approach to the study of speech perception from a direct-realist perspective. *Journal of Phoenetics*, **14**, 3-28.

Hirsh, I. J., & Watson, C. F. (1996). Auditory psychophysics and perception. *Annual Review of Psychology*, **47**, 461-484.

Hoye, W., Dickinson, A., Banos, H., & Gierock, S. (2000). Executive functions and continuous visual memory test performance in a general neuropsychological sample. *Archives of Clinical Neuropsychology*, **15(8)**, 685-686.

Jiang, Y., & Leung, A. W. (2005). Implicit learning of ignored visual context. *Psychonomic Bulletin and Review*, **12**(1), 100-106.

Kalyuga, S., Chandler, P., & Sweller, J. (2004). When redundant on-screen text in multimedia technical instruction can interfere with learning. *Human Factors: The Journal of Human Factors and Ergonomics Society*, **3**, w567-581.

Lechuga, M. T., Moreno, V., Pelegrina, S., Gomez-Ariza, C. J., & Bajo, M. T. (2006). Age differences in memory control: Evidence from updating and retrieval-practice tasks.  *Acta Psychologica*, **123**, 279-298.

Leech, G., Rayson, P., & Wilson, A. (2001). *Word frequencies in written and spoken English: Based on the British National Corpus*. London: Longman.

Liberman, A. M. (1996).  *Speech: A special code*. Cambridge MA: MIT Press.

Moreno, R., & Mayer, R. E. (2001). A coherence effect in multimedia learning: The case for minimizing irrelevant sounds in the design of multimedia instructional messages.  *Journal of Educational Psychology*, **93(1)**, 187-198.

Papinikolaou, K. A., Grigoriadou, M., Magoulas, G.D., & Kornilakis, H. (2002). Towards new forms of knowledge communication: The adaptive dimension of a web-based learning environment. *Computers and Education*,**39(4)**, 333-360.

Paivio, A., Yuille, J. C., & Madigan, S. A. (1968). Concreteness, imagery, and meaningfulness values for 925 nouns. *Journal of Experimental Psychology, Monograph Supplement*, **76(1)**, 1-25.

Ryan, M., Carlton, K. H., & Ali, N. S. (1999). Evaluation of traditional classroom teaching methods versus course delivery via the World Wide Web. *The Journal of Nursing Education,* **38(6)**, 272-277.

Saada-Robert, M. (1999). Effective means for learning to manage cognitive load in second grade school writing: A case study. *Learning and Instruction*, **9(2)**, 189-208.

Smith, H. J., Higgins, S., Wall, K., & Miller, J. (2005). Interactive whiteboards: Boon or bandwagon? A critical review of the literature. *Journal of Computer Assisted Learning*, **21(4)**, 91-104.

Sweller, J. (1988). Cognitive load during problem solving: Effects on learning. *Cognitive Science*, **12**, 257-285.

Tindall-Ford, S., Chandler, P., & Sweller, J. (1997). When two sensory modes are better than one. *Journal of Experimental Psychology*, **3(4)**, 257-287.

Wall, K., Higgins, S., & Smith, H. (2005). ‘The visual helps me understand the complicated things’: Pupil views of teaching and learning with interactive whiteboards. *British Journal of Educational Technology*, **36(5)**, 851-867.

Table 1.

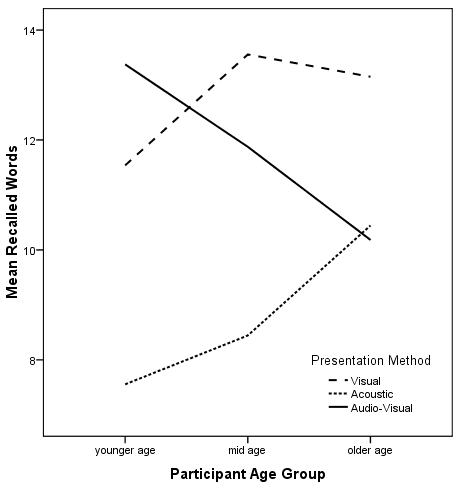
Table 1: Mean correct words (and Standard Deviations) recalled by participants as a function of participant age group and presentation method.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Younger-Age Participants | Mid-Age Participants | Older-Age Participants | Total |
| Visual Presentation | 11.54 (2.9) | 13.56 (2.6) | 13.15 (3.2) | 12.74 (3.0) |
| Acoustic Presentation | 7.56 (2.1) | 8.44 (2.9) | 10.44 (4.0) | 8.50 (3.0) |
| Audio-Visual Presentation | 13.38 (3.4) | 11.88 (1.8) | 10.18 (2.8) | 12.00 (3.0) |
| Total | 10.64 (3.8) | 11.41 (3.0) | 11.72 (3.5) | 11.21 (3.5) |

Figure Caption:

Figure 1: Interaction between age group and presentation method for the mean number of correctly recalled words.

Figure 1.



Appendix A.

Word List Used in the Current Research, Shown in the Order Presented to Participants:

Flower, Anger, Corn, Truth, Shoes, Belief, Car, Effort, Apple, Theory, Bird, Moral, Fire, Knowledge, Table, Freedom, River, Chance, Heart, Mood, Radio, Fate, Window, Interest, Doctor, Idea, House, Hope, Rock, Honour.

Appendix B.

Table illustrating the number of concrete and abstract words from the word list displayed in frequency per million words (in both spoken and written English) categories based on Leech *et al.’s* (2001) frequency guidelines.

|  |  |  |  |
| --- | --- | --- | --- |
| Frequency Per Million Words | Highly Concrete | Highly Abstract | Total |
| 20-39 | 4 | 4 | 8 |
| 40-59 | 2 | 2 | 4 |
| 60-79 | 2 | 2 | 4 |
| 80-99 | 2 | 1 | 3 |
| 100-119 | 2 | 1 | 3 |
| 120-139 | 2 | 2 | 4 |
| 140-159 | 0 | 1 | 1 |
| 200-219 | 0 | 1 | 1 |
| 260-279 | 1 | 1 | 2 |
| Total | 15 | 15 | 30 |