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Abstract:

This paper describes an investigation into the relationship between a user's cognitive style and their performance on a multimedia application. The application was designed to present information in users' preferred and non-preferred cognitive style. The investigation looked at the difference in performance between Verbalisers, Bimodals and Imagers in areas of the application that presented information either as text and narrative or as a succession of images.

Initially no significant difference was found between users in supported and non-supported areas of the application, although the differences were approaching significance ($p=0.067$). When Bimodals were excluded from the study, a significant difference was found ($p<0.01$). Verbalisers and Imagers were also found to be more likely to select a presentation in a matched cognitive style ($p<0.05$). These results are discussed in relation to individual cognitive style and the potential for the individual configuration of multimedia.

1 Introduction

The purpose of this study was to investigate how fundamental differences in the way individuals see the world, their cognitive style, was related to differences in their performance in a computer based multimedia application. The concept of cognitive style has been described as an underlying personal characteristic that is able to explain many of the features of the way we think and learn. Tennant [13] states that cognitive style, learning style and conceptual style are related terms which refer to an '*individual's characteristic and consistent approach to organising and processing information*'. The concept of learning strategy is closely related to learning or cognitive style. Riding and Read [8] distinguish between learning style and learning strategy. Learning style is a relatively fixed characteristic of an individual and is seen to be independent of intelligence though it will be likely to affect performance in tasks. Learning strategies will also affect performance, but are learned in response to particular problems to provide specific solutions to problems of acquiring learning. In this paper the term learning style is used to mean the same as cognitive style.

The concept of cognitive styles originated from the work of Witkins [15], who discovered a fundamental difference in people's perceptual judgement. Some people were able to align a rod accurately to the vertical in a tilted frame and were classified as field independent. Others tended to align the rod to the frame irrespective of orientation and these were classified as field dependent. Differences in field dependent and field independent cognitive styles were physiological and reflected many other differences in how people perceive and think according to Witkin.

Several different types of cognitive or learning style have been suggested since Witkin's initial work. Kolb and Fry [4] have suggested four types of learning style, based upon their experiental learning system, the Learning Styles Inventory. Other suggested learning styles include Surface – Deep [3] and Serialist – Holist [2].

1.1 Wholist/Analyst – Verbaliser /Imager (WAVI) cognitive styles.

Riding [9] has described two bipolar dimensions of cognitive style, the Wholist – Analyst (WA) and Verbaliser – Imager (VI) dimensions. The WA dimension describes whether individuals process information in wholes or in parts. The VI dimension classifies whether individuals represent or perceive in words or as pictures. The WA and VI scales are independent, so the position of an individual on the WA scale does not influence their position on the VI scale. It is likely that such fundamental differences in thinking and perception will be important in how we assimilate and interact with computer presented information. It was decided therefore, to investigate how a user's position on Riding's VI scale related to their performance in a multimedia application configured to support or not to support the user's cognitive style.

An experiment was performed to measure performance by learners in a multimedia application configured to support different cognitive styles. It was then intended to relate performance on multimedia presented tests to participants' cognitive style as measured by a Riding's [11] computer based Cognitive Styles Analysis (CSA) test.

2 Design of the application

The multimedia application used in the investigation was as described by Barker and colleagues [1]. The programme delivered an English Language comprehension skills course based on a non computer-delivered course already in use in a Further Education (FE) college basic language skills workshop.

The application presented stories or scenarios based on simple situations commonly encountered in everyday life as a series of images or as a sequence of text and narrative. A set of questions about the story were presented immediately after each presentation and in the same format as the presentation, i.e. either as images or text. A multimedia language test based on the work of Vaughan [14] and a multimedia tool to measure participants' evaluation of the quality of the application were integrated into the application. The application was designed so that all navigational and login data, participants' scores from the question section and evaluation results were saved securely to file.

3 Participants

Participants were volunteer learners recruited from basic skills support and learning centres in a college of Further Education. All reported being experienced computer users. All participants had English as their first language and had scored greater than 60 percent on a multimedia delivered language screening test. The following table summarises characteristics of the participants.

Table 1

Characteristics of participants undertaking the learning styles and multimedia experiment.

Number (n)	Male To Female M/F	Age range	Average age	Wholist Analyst (WA) Range	Verbaliser Imager (VI) Range	Mean language test score %
51	1.43	16-21	19.3	0.67-1.8	0.72-1.87	78.2%

Participants were classified into three groups by dividing them along VI dimension, producing 17 Verbalisers, 17 Bimodal and 17 Imagers [9].

4 Method

The course was completed in a single session at the participants own pace and was fully supervised at all times. After a short induction a language screening test followed by Ridings CSA test [11] were administered. The course itself consisted of five scenarios, two verbal scenarios and two image based scenarios, assigned randomly by the computer and a choice. Participants selected the presentation mode of the fifth scenario themselves. After each section had been completed, users answered questions about details of the scenario presented in the section. All answers to questions and other data were saved securely to network file servers for later analysis. Immediately after completion of the course, participants were asked to undertake a multimedia questionnaire to record their assessment of the application's quality. Participants were able to take a break at any time during the experiment, but only at the end of completed sections of the course. The complete procedure took between one and a half to three hours.

5 Results

Table 2 presents scores obtained by Verbalisers, Bimodals and Imagers in areas of the course where their preferred cognitive style matched the presentation style (supported areas), where their preferred cognitive style did not match the presentation style (non-supported areas) and in chosen sections.

Table 2

Scores obtained by participants in sections of the course, supported (score in), non-supported (score out) and chosen presentations cognitive style for Verbalisers, Bimodals and Imagers.

Group	N	Mean VI score	Mean Evaluation score %	Mean Score in	Mean Score out	Mean score in chosen section
All Verbalisers, Bimodals and Imagers	51	1.28	73.8%	64.7	62.5	66.7
Verbaliser	17	0.87	69.8%	66.3	61.3	65.1
Bimodal	17	1.27	74.7%	62.9	65.2	71.8
Imager	17	1.60	76.9%	64.6	61.0	63.2

Table 3 shows the percentage of Verbalisers and Imagers divided at the mid point along the

VI scale selecting text and image based presentations in the chosen section of the course.

Table 3 The percentage of Verbalisers and Imagers selecting text and image based presentations in the chosen section of the course		
Group	Percentage selected Visual presentation	Percentage selected Verbal presentation
Verbaliser	32%(8)	68%(17)
Imager	77%(20)	23%(6)

5.1 Analysis of Variance

Table 4 below displays within subject effects of an ANOVA performed on scores obtained by participants in supported and no-supported sections of the course.

Box's Test of Equality of Covariance Matrices was employed to tests the null hypothesis that they were equal. The observed value of $p > 0.05$ (0.46) compels us to accept the null hypothesis. Mauchly's test was employed to test the sphericity of the data within groups which is also assumed within the ANOVA used. The observed value of $p > 0.05$ (1.0) compels us to accept the null hypothesis and assume sphericity of data

Table 4

Tests of Within Subject Effects

Results of repeated measures ANOVA performed on scores obtained By Verbalisers, Bimodals and Imagers on supported and non-supported areas of the course

Source	Type III Sum of Squares	df	Mean Square	F	Sig..
Test Scores	112.245	1	112.245	3.514	0.067
Test Scores x GROUP	255.152	2	2.613	3.994	0.025
Error (Test Scores)	1533.353	48			

The value of p = 0.067 for the within subject effects is taken to indicate that any differences between scores in supported and non-supported areas of the course for Verbalisers, Bimodals and Imagers obtained in this study are ascribable to chance alone. The value of p = 0.067 however is approaching significance. There is also a significant interaction between Test scores and Group (p = 0.025), suggesting that group composition may be influencing the dependant variable (test scores).

Table 5 shows between subject effects of an ANOVA performed on scores obtained by participants in supported and no-supported sections of the course.

Table 5

Tests of Between Subject Effects
Results of repeated measures ANOVA performed on obtained by Verbalisers, Bimodals and Imagers

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Intercept	205835.29	1	205835.29	761.4	0.000
GROUP	14.875	2	7.438	0.028	0.973
Error	1533.353	48			

The value of p = 0.973 for the GROUP variable indicates that there were no significant differences between the performance of Verbalisers, Bimodals and Imagers on the course as a whole

Table 6 below presents the results of a non-parametric test of significance on the user evaluation data summarised in table 2 above for Verbalisers, Bimodals and Imagers.

Table 6 Kruskall-Wallace analysis of user evaluation data For Verbalisers, Bimodals and Imagers groups		
	N	Mean Rank
Verbalisers	17	20.82
Bimodals	17	28.41
Imagers	17	28.76
Total	51	
Chi square		3.143
df		2
Sig.		0.208

The value of Chi square (3.143, 2df) is not significant (p=0.208). The null hypothesis is therefore accepted and we conclude that any difference in user satisfaction between Verbalisers, Bimodals and Imagers could be ascribed to chance alone. The failure to detect any difference between user satisfaction with the application between groups might be because evaluation was carried out at the end of the experiment. Subjects had experience of similar amounts of exposure to supported and non-supported sections of the application, there was little difference in their appreciation of the application as a whole. The application was evaluated rather highly on average (73.8%), though the perceived quality of the application would be influenced by many factors other than cognitive style.

5.2 The effect of Bimodal users:

The significance of the differences in the mean scores for supported and non-supported areas (p=0.067) was approaching significance, though the effect of a significant interaction between the test scores and group variable (p=0.025) may have influenced the result. The effect of Bimodal participants, i.e. those with a both Verbaliser and Imager attributes, have been reported as complicating the investigation of the influence of cognitive style on learning [5]. These participants reduce the effect of any differences present in participants at the extremes of the VI dimension.

Kwok and Jones' [5] solution to this problem was to eliminate Bimodal learners from their investigation. Their study of navigational behaviour in followers of a multimedia course initially found no differences between serialist and holist participants. Only when they excluded versatile learners (those scoring in the middle of the serialist – holist range), from their study, significant differences were found.

It was decided to analyse the data summarised in table 3 and to exclude Bimodals from the analysis. The significance of differences between the scores of Verbalisers and obtained by excluding Bimodal learners are displayed in table 7 below.

Table 7

Tests of Within Subject Effects
Results of repeated measures ANOVA performed on scores obtained
By Verbalisers and Imagers when Bimodals are excluded

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Test Scores	313.471	1	313.471	9.365	0.004
Test Scores x GROUP	9.191	1	9.191	0.275	0.604
Error (Test Scores)	1071.088	32			

The results of this analysis show that when Bimodal participants are excluded from the study, there is a significant difference between performance in supported and non-supported areas of the course. The interaction Test Scores x GROUP is no longer significant. This suggests that the interaction between Bimodal group and the Test Scores influenced the results obtained in table 4 above.

The following table presents the results of a Chi Square tests performed data summarised in table 3, the percentage of Verbalisers and Imagers selecting text and image based presentations in the chosen section of the course with Bimodals excluded.

Table 8

Results of Chi square test performed on data summarised in table 3, the percentage of Verbalisers and Imagers selecting text and image based presentations in the chosen section of the course.

Chi Square	10.882
df	3
Sig.	0.012

The value of chi square (10.882, 3df) is significant at the $p<0.05$ level ($p=0.012$). This shows that on average Verbalisers are more likely to choose a verbal presentation and Imagers a visual one.

6 Discussion

In this experiment, performance on a multimedia course configured for different cognitive styles was investigated. The data obtained in the experiment and the results of statistical analysis showed no significant difference in performance between participants in areas of the course where their preferred learning style, as measured by Riding's CSA test, was supported and areas where it was not. Differences between Verbalisers and Imagers, although not significant, were approaching significance ($p=0.067$). When the influence of Bimodals was allowed for, significant differences in the performance of Verbalisers and Imagers as measured by test scores was found in supported and non-supported areas of the course ($p<0.01$). There were also significant differences between Verbalisers and Imagers in their choice of a verbal or image based presentation. These results suggest that individual cognitive style is important in user interface design. Although many users are Bimodal and are able to benefit from a range of presentation formats, the performance of users at the extremes of the VI cognitive style dimension was influenced by the presentation mode. Users performed significantly better when cognitive styles were matched and were more likely to select a matched cognitive style when given the choice.

The results of this study on cognitive style and multimedia are consistent with studies performed in other domains. For example, Riding and Sadler-Smith [10] were able to show that the effectiveness of a learning package presented in text or image format could be related to learning style. Riding and Watts [12] studied the effect of cognitive style on the preferred formats of learning materials. They found that Imagers were more likely to select picture based presentations and Verbalisers were more likely to choose text based ones. In text plus picture presentations, Imagers performed better than Verbalisers. When text was presented without pictures, Verbalisers performed better than Imagers.

Pillay and colleagues [7] have suggested that learning materials can be designed to accommodate preferred cognitive styles, based on an investigation of cognitive style and performance. Although in their work, they failed to find significant differences in the performance of learners with materials matched and mis-matched to their cognitive style, they conclude that subject content may have an affinity for certain cognitive styles. They further conclude that the design of CBI materials can benefit greatly by considering the needs for personal learning styles. Liu and Reed [6] also suggest that there is a great potential for using hypermedia to support individual learning style.

The ability to configure a computer application for an individual is an exciting prospect for the future. Techniques in the field of artificial intelligence and human computer interaction might be applied to the richness of the multimedia environment to create individually configured, highly usable applications.

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