

The effect of the Visual-Auditory dimension of cognitive style

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Abstract. This paper is concerned with the effect that the Visual-Auditory dimension of cognitive style has on users of multimedia systems. The relative performance of users cannot be explained by examining their cognitive style classification that is calculated by a purely visual test. Therefore an extension to the visual classification is proposed that reflects the way individuals' perceive information that is presented using both audio and video. This paper reviews the visual definition of cognitive style and the auditory dimension. Then the performance of subjects in a series of experiments is analysed to assess whether the new definition of cognitive style explains their behaviour.

Keywords. Human Interfaces and Interaction, Multimedia, Cognitive style.

1. Introduction

This paper is concerned with the effect that the Visual-Auditory dimension of cognitive style has on users of multimedia systems. First cognitive style as calculated using a purely visual test is defined, and then a proposed extension to the definition that distinguishes between the perception of visual and auditory information is discussed. Next the performance of subjects in a series of experiments are analysed to assess whether the new definition of cognitive style more adequately explains their behaviour than the visual definition alone.

2. Cognitive style

A cognitive style is the consistent underlying method of an individual's thinking and

perceiving that affects the way they perceive and respond to events and ideas [6] [10] [11].

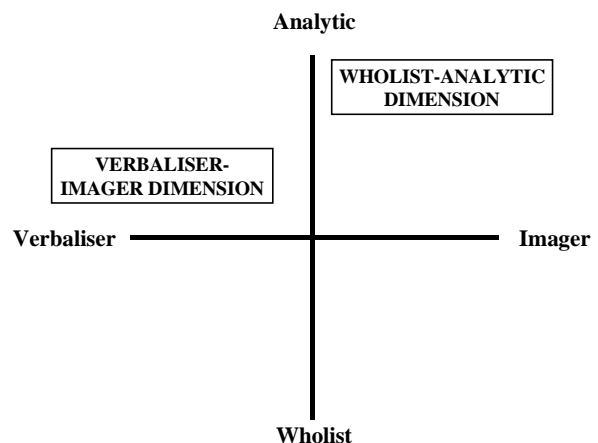


Figure 1: The two cognitive style dimensions

Riding and Cheema [8] reviewed over 30 methods of defining cognitive style and concluded most could be grouped within two fundamental independent cognitive style dimensions; the Wholist-Analytic dimension and the Verbal-Imagery dimension. A person's position along the Wholist-Analytic dimension reflects whether they understand situations as a whole or see things in parts, while their position along the Verbal-Imagery dimension reflects the manner in which they represent information while thinking, either as words or mental pictures or images.

The Cognitive Styles Analysis (CSA) program was produced as a computerised test that automatically calculates the cognitive style of individuals along both dimensions [6] [7]. The relative speed in which individuals answer the different style of questions determines their cognitive style [9].

The CSA classification of cognitive style was not successful in accurately predicting the performance of individuals in an experiment that presented complex tasks using multimedia [1]. Cognitive style was found to have an influence on the performance of subjects, however the tasks subjects performed in the experiment were complex and contained aspects that were suitable for different cognitive style groups. The combination of media used in the experiment was identified as a factor that may have influenced the performance of subjects.

A second set of experiments was designed to examine the effect that different media had on the performance of subjects in a range of simple tasks. A description of the tasks can be found in [2] [3] and [4]. As in the first set of experiments there were indications that cognitive style was affecting performance but the effects were not consistent across media and not all were as predicted. The type of activities involved in the tasks also had a strong influence on performance. Few differences were found between the cognitive style groups and these were only discovered in the relatively more complex tasks.

In order to explain these differences in performance the way users perceive different types of computerised media was investigated. A new experiment was devised to test whether the classification of an individual's cognitive style would be the same when the test used visual information or auditory information.

3. The Visual-Auditory dimension

The relative performance of 24 subjects in a visual version of the CSA test were compared to their performance in an auditory version [5]. There was low correlation between the performance of subjects using the visual and auditory versions of the CSA test which indicated that visual and auditory information are processed in a different manner and conform to different cognitive styles. These activities are affected by the parts of the brain that receive the information and the rate in which the information arrives. Different parts of the brain are dedicated for receiving visual and auditory information. Auditory information is presented serially at a rate that is determined externally to the individual. Visual information in contrast is gathered by the scanning movements of the eye which allows information to be gathered in a

non-serial manner and at a rate that is determined by the individual.

An extension to the visual classification of cognitive style is proposed that includes a Wholist-Analytic and Verbal-Imagery classification for visual information and a Wholist-Analytic and Verbal-Imagery classification for auditory information.

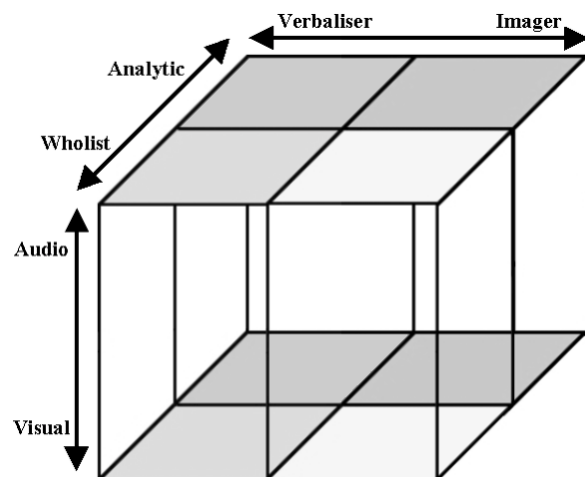


Figure 2: Adding a visual and auditory dimension to the cognitive style model

Figure 2 shows the effect of adding an auditory dimension to the visual cognitive style model. A person's cognitive style is calculated by performing the visual CSA test augmented with the auditory experiment. The first half produces ratios for the visual Wholist-Analytic dimension and visual Verbal-Imagery dimension (the bottom plane in figure 2) and the second half produces two ratios for the auditory Wholist-Analytic dimension and auditory Verbal-Imagery dimension (the top plane in figure 2).

An assessment of an individual's Visual-Auditory dimension can be made for both the Wholist-Analytic and Verbal-Imagery dimensions by comparing the performance in the visual and auditory experiments. For both the Wholist-Analytic and Verbal-Imagery dimensions a ratio was calculated with the range of 0.00 to 2.00. A figure of greater than 1.00 indicated that the subject performed the visual version better than the auditory version.

The visual and auditory ratios for the Wholist-Analytic dimension and for the Verbal-Imagery dimension were calculated for all subjects who performed the experiment. The

median value was selected as the preferred dividing point as it removes the effect of abnormally high or low subject classifications (VsAu_VI = 1.270, VsAu_WA = 1.513). Above the median point subjects are classified as visual while below the median point subjects are classified as Auditory.

The results of the original set of experiments were examined to determine whether the new classification of visual and auditory cognitive style was capable of explaining the performance of individuals.

3.1. The first set of experiments

The first set of experiments compared the performance of subjects using different interfaces that were designed to suit different cognitive styles. In the Wholist-Analytic tasks users were presented with information in a Wholist or Analytic style and then answered a set of twenty multiple-choice questions. The Wholist version presented information with a predetermined structure (sequentially and at a constant rate) while the Analytic version allowed subjects to impose their own structure on the information (subjects control the order and speed). The Verbal-Imagery tasks involved subjects entering information in a database. In the Verbaliser version subjects selected text labels while in the Imager version subjects selected images [1]. There were indications that cognitive style had an effect for individual measures of performance although this effect was not always as predicted.

The performance of individual subjects in the first set of experiments was examined to ascertain whether their performance can be explained by either their visual or auditory classifications of cognitive style as defined by the visual and auditory experiments. The Visual-Auditory classification was assessed for four of the subjects who performed the first set of experiments (table 1).

The columns show the visual (Vs) and auditory (Au) Wholist-Analytic (WA) and Verbal-Imagery (VI) classification of each subject listed by their ID number in the first set of experiments (3, 6, 12 and 16). The subjects' cognitive style is indicated by the initial; Wholist (W), Analytic (A), Verbaliser (V) or Imager (I). The Visual-Auditory ratio is displayed for the

Wholist-Analytic (VsAu_WA) and Verbal-Imagery (VsAu_VI) dimensions indicating whether the subjects are more visual (Vs) or auditory (Au).

Table 1: Visual and auditory classification of subjects

Subject ID	3	6	12	16
Vs_WA	A	W	A	A
Vs_VI	V	V	V	V
Au_WA	A	A	A	W
Au_VI	I	V	I	V
VsAu_WA	Vs	Au	Vs	Au
VsAu_VI	Au	Au	Au	Au

Table 2: Subjects performance in the first set of experiments

Subject ID	3	6	12	16
W * A Tasks	N	Y	N	Y
V * I Tasks	Y	Y	Y	Y

Table 2 shows the relative performance of the four subjects (3, 6, 12 and 16) in the Wholist-Analytic tasks (W * A Tasks) and the Verbal-Imagery tasks (V * I Tasks). Wholists were expected to perform the Wholist task better than the Analytic task, Analytics were expected to perform the Analytic task better than the Wholist task, Verbalisers were expected to perform the Verbaliser task better than the Imager task and Imagers were expected to perform the Imager task better than the Verbaliser task. In addition Auditory subjects were expected to perform the Wholist task better than the Analytic task as it contained more auditory information. The columns indicate whether the subject's relative performance between the different styles of task was as expected for either their visual cognitive style or their auditory cognitive style (Y = yes, N = No).

Some of the subjects performed the tasks in a manner that matched their visual cognitive style while others performed the tasks in a manner that matched their auditory cognitive style. In the Wholist-Analytic tasks the performance of only two subjects can be explained by their visual or auditory cognitive styles. Subject number 6 performed the Wholist task better which matched their visual Wholist-Analytic style, while subject number 16 performed the Wholist task better which matched their auditory Wholist-Analytic

style. The other two subjects also performed the Wholist tasks better which did not match either their visual or auditory Wholist-Analytic styles.

In the Verbal-Imagery tasks the performance of all subjects can be explained by their visual and auditory cognitive styles. Subjects 3, 6 and 16 performed the Verbaliser task better which matched their visual Verbal-Imagery style, and subject number 12 performed the Imager task better that matched their auditory Verbal-Imagery style.

While it is possible to explain the performance of subjects with reference to their visual and auditory cognitive style it was not possible to predict whether the visual or auditory cognitive style dimension would have more influence on performance in tasks that used visual and auditory interfaces by examining the Visual-Auditory ratio.

3.2. The second set of experiments

The performance of individual subjects in the second set of experiments was examined to test whether their performance can be explained by their visual and auditory classification. The Visual-Auditory classification was assessed for eleven of the subjects who performed the first set of experiments (table 3).

Table 3: Visual and auditory classification of subjects

	1	6	13	15	19	21	23	30	31	32	41
WA Vs	A	A	A	A	A	A	W	A	A	A	W
VI Vs	V	I	V	I	V	I	I	V	V	I	I
WA Au	W	A	A	A	W	W	W	W	W	W	W
VI Au	V	V	V	V	V	V	I	I	I	V	I
WA VsAu	Vs	Au	Au	Au	Vs	Vs	Vs	Au	Au	Au	Vs
VI VsAu	Au	Vs	Au	Au	Au	Vs	Vs	Vs	Vs	Vs	Au

Table 4 shows the relative performance of the eleven subjects in the tasks performed in the second set of experiments. The media is represented by the initial: text (T_), image (I_), text and image (TI_), audio (A_) and video (V_). The tasks are represented by the abbreviations: *procedural* task questions that did not include calculations (PNC), *procedural* task questions that included calculations (PWC), *configuration* (CFG), *type of objects* (TOB), *physical attributes of objects* (POB), general *comprehension* questions (GCO), and detailed *comprehension*

questions (DCO). Each task was classified in terms of which cognitive style group it was expected to suit. The performance of subjects in tasks that were expected to suit opposite cognitive styles were compared.

Table 4: Subjects performance in the second set of experiments

Subject ID	1	6	13	15	19	21	23	30	31	32	41
T_PNC*	O	Y	Y	N	O	Y	Y	Y	O	O	Y
T_PWC	O	N	N	N	Y	O	Y	Y	O	O	Y
I_TOB*	O	N	N	N	Y	O	Y	Y	O	O	Y
I_POB	O	N	N	N	Y	O	Y	Y	O	O	Y
TI_PNC*	O	N	N	N	O	O	N	Y	Y	O	Y
TI_PWC	O	N	N	N	O	O	N	Y	Y	O	Y
A_PNC*	Y	N	N	N	Y		N	Y	O	Y	Y
A_PWC	Y	N	N	N	Y		N	Y	O	Y	Y
V_GCO*	Y	N	N	N	Y	Y	Y	Y	Y	Y	Y
V_DCO	Y	N	N	N	Y	Y	Y	Y	Y	Y	Y
T_CON*	N	O	N	Y	N	Y	Y	O	O	Y	Y
T_OBJ	N	O	N	Y	N	Y	Y	O	O	Y	Y
A_CON*	N	O	N	O	N	O	Y	Y	Y	O	Y
A_OBJ	N	O	N	O	N	O	Y	Y	Y	O	Y
V_DCV*	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y
V_DCI	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y
T_PNC*	Y	Y	Y	Y	Y	Y	Y	Y	O	O	Y
I_CFG	Y	Y	Y	Y	Y	Y	Y	Y	O	O	Y
TI_PNC*	Y	O	Y	O	Y	O	Y	Y	Y	O	Y
TI_CFG	Y	O	Y	O	Y	O	Y	Y	Y	O	Y
A_PNC*	Y	Y	VA	Y	Y	Y	Y	Y	Y	Y	Y
I_CFG	Y	Y	VA	Y	Y	Y	Y	Y	Y	Y	Y
V_PRO*	Y	Y	VA	Y	Y	Y	Y	Y	Y	Y	Y
I_CFG	Y	Y	VA	Y	Y	Y	Y	Y	Y	Y	Y
A_PNC*	Y	Y	VA	Y	Y	Y	Y	Y	Y	Y	Y
TI_CFG	Y	Y	VA	Y	Y	Y	Y	Y	Y	Y	Y
V_PRO*	Y	Y	VA	Y	Y	Y	Y	Y	Y	Y	Y
TI_CFG	Y	Y	VA	Y	Y	Y	Y	Y	Y	Y	Y

Tasks are labelled in order of which cognitive style group was expected to perform the tasks best. Wholist or Verbaliser style tasks are written first and Analytic or Imager style tasks are written second, for example in the first pair of tasks (T_PNC*T_PWC) the first task the text *procedural* task questions that do not include calculations (T_PNC) were expected to suit Wholists, while the second task the text *procedural* task questions that included calculations (T_PWC) were expected to suit Analytics.

- The first three rows compare the performance of subjects in Wholist-Analytic tasks with a visual presentation. It was expected that subjects would perform better in the style of task that matched their visual Wholist-Analytic style.
- A_PNC*A_PWC compares the performance of subjects in Wholist-Analytic tasks with an auditory

presentation. It was expected that subjects would perform better in the style of task that matched their auditory Wholist-Analytic style.

- V_GCO*V_DCO compares the performance of subjects in Wholist-Analytic tasks with a presentation that contains visual and auditory information. It was expected that subjects would perform better in the style of task that matched either their visual or auditory Wholist-Analytic styles.
- T_CON*T_OBJ compares the performance of subjects in Verbal-Imagery tasks with a visual presentation. It was expected that subjects would perform better in the style of task that matched their visual Verbal-Imagery style.
- V_DCV*V_DVI compares the performance of subjects in Verbal-Imagery tasks with a presentation that contains visual and auditory information. It was expected that subjects would perform better in the style of task that matched either their visual or auditory Verbal-Imagery styles.
- T_PNC*I_CFG and TI_PNC*TI_CFG compare the performance of subjects in Wholist-Analytic and Verbal-Imagery tasks with a visual presentation. It was expected that subjects would perform better in the style of task that matched either their visual Wholist-Analytic or Verbal-Imagery styles.
- The last four rows compare the performance of subjects in Wholist-Analytic and Verbal-Imagery tasks between visual and auditory presentations. It was expected that subjects would perform better in the style of task that matched either their visual or auditory Wholist-Analytic or Verbal-Imagery styles.

Table 4 indicates whether the relative performance of subjects between each pair of tasks can be explained by their cognitive style (Y indicates a match with their expected visual or auditory cognitive style, O indicates a match with the opposite visual or auditory cognitive style, VA indicates a match for the Visual-Auditory ratio and N indicates no match with either their visual or auditory cognitive style.

Out of 154 comparisons displayed in table 4 two thirds were performed as expected in a manner that matched their visual or auditory cognitive style. Out of the third that did not perform as expected half performed in a manner that matched the opposite visual or auditory cognitive style. For these subjects the opposite visual or auditory cognitive style had more influence over their performance. Four of the calculations did not suit either the visual or auditory cognitive styles of the subject but did suit their Visual-Auditory ratio as they performed the audio task better than the visual task which matched the Visual-Auditory ratios for both their Wholist-Analytic and Verbal-Imagery dimensions. The remaining 22 calculations did not match either the visual or auditory Wholist-Analytic and Verbal-Imagery styles.

Only one subject performed all tasks as expected (subject number 41) who was classified as a Wholist/Imager for both visual and auditory classification. Other subjects who performed as expected in all but one or two calculations (subject number 30 and subject number 23) had different cognitive style classifications which showed that the measurements were not biased for subjects with one particular cognitive style classification.

The classification of visual and auditory cognitive styles makes it easier to explain past behaviour in the majority of cases but it does not make it easier to predict the performance of complex tasks that have aspects that could suit more than one cognitive style dimension and presents a mixture of visual and auditory information.

4. Conclusion

This paper examined the Visual-Auditory classification of cognitive style in order to explain the behaviour of users of multimedia systems. While in the majority of cases the visual and auditory definition of cognitive style makes the performance of subjects understandable it is not precise for a large number of cases, and it does not help in the prediction of performance in complex tasks. It was not possible to predict whether the visual or auditory cognitive style dimension would have more influence on the performance of subjects in tasks that presented a combination of visual and auditory information

by examining the Visual-Auditory ratio. Further research is needed to test the effect of the visual and auditory definition of cognitive style before it can be reliably used as an attribute of the user that multimedia systems can adapt themselves to suit.

5. References

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