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Information-processing and perceptions of control: How attribution style affects task-relevant processing.

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ABSTRACT

This study investigated the effects of perceived controllability on information processing within Weiner's (1985, 1986) attributional model of learning. Attributional style was used to identify trait patterns of controllability for 37 university students. Task-relevant feedback on an information-processing task was then manipulated to test for differences in working memory function between participants with high versus low levels of trait controllability. Processing efficiency occurred differently for hi-trait and lo-trait types. Results supported the hypothesis that trait controllability exerts a moderating effect on the way task-relevant feedback is processed. A selective encoding of information was evident, involving processing limitations inherent to the working memory system. These findings mark an important consideration for the way in which information is presented during the learning process.

Keywords Working Memory (WM), Executive Processes, Attributional Style, Trait Controllability, Spontaneous Causal Search.

INTRODUCTION

An interest in how the cognitive abilities of students interact with the instruction they receive as a learner has provided the impetus for this study. Experience as a lecturer in educational psychology expanded this interest, and, as awareness grew concerning the degree to which cognitive curricula focused on directing selective attention to congruent, task-relevant information, a motivation to understand how these same curricula were dealing with incongruent, irrelevant information began to develop. From this, an interest in how information is integrated during the learning process, as well as how the integration is affected by component processes linked to the learning, led to the current investigation. The underlying focus for this investigation concerns how changes to the congruency of achievement information affect the overall integration of information.

Research aimed at cognitive learning suggests that cognitive and neuropsychological processes provide the intellectual basis for student learning; encompassing both literacy-based

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(Berninger, 1999; Berninger & Cowell, 1985) and numeracy-based (Bernardo, 1999; Kintsch & Greeno, 1985) domains of learning (see also Byrnes, 2001; Byrnes & Fox, 1998, Goswami, 2004). At the heart of these processes stand what are known as the executive information processing functions generally associated with the *working memory* (WM) system, including salient attentional sequencing, the inhibition of irrelevant information, information organisation, and the integration of cognitive and behavioural processes (Anderson, 2000; Ashman & Conway, 1997; Baddeley, 2001; Denckla, 1996; Engle, 2002; Fan et al., 2002; Karatekin, 2004). These WM executive control processes are cognitive operational processes that act to maintain and manipulate information in line with the relevant goals and planning of a task. Key control functions include response monitoring, essential to maintaining attentional focus onto task-relevant information (Corbetta et al, 1995), and error detection, necessary for identifying irrelevant or conflicting information (Cohen, Botvinick, & Carter, 2000). Although primitive sensory encoding may initially control the way information is processed by encapsulating the information in an innate, automatically driven fashion (Fodor, 1985; Pinker, 1997), it is the executive control processes of WM that ultimately control a student's information processing capabilities. Indeed, selective information processing, essential to every aspect of learning, is possible precisely because the component processes of WM are able to integrate information in a holistic manner, allowing WM to act as a sort of gatekeeper to the learning process. An understanding of what affects these processes, and how they might in turn affect learning, is, therefore, viewed as critical to the ongoing development of effective instructional techniques. However, according to several prominent educational psychologists (Byrnes & Fox, 1998; Conway & Ashman, 1991; Goswami, 2004; Smith, 2004), a problem exists in that traditionally the application of cognitive and neuropsychological knowledge has not been well supported by the classroom teacher. The current study investigates one aspect of this knowledge, the role of WM processes that deal with information that is irrelevant or incongruent to the learning task, and the implications this may have for classroom learning.

Controllability and learning

A second theoretical area of interest to the study is that of *attribution theory*. Attribution theory is concerned with how individuals perceive the relationship between cause and effect in various situations, making cognitive links which are then used to account for the actions and motives of themselves and others. Though links between WM processing and attribution theory may appear tenuous, several aspects of attribution theory are quite fundamental to the sorts of cognitive processing a learner undertakes. For example, Weiner's (1985, 1986) notion of controllability (viz., the perceived expectations of being able to control an achievement outcome) suggests that instructional practices designed to facilitate a learners' self-efficacy (Bandura, 1965, 1986: the belief that one is capable of achieving desired learning outcomes or performance goals) will strengthen achievement motivation over time, leading to increased engagement and greater self-regulation of the learning. Self-efficacy and controllability both represent cognitions related to the learner's beliefs concerning their ability to control a situational outcome, that is, both represent a cognitive factor, intrinsic to the learner, which affects both the motivation and manner in which the individual will process task-relevant achievement information. However, how the processing of irrelevant or distracting achievement information might feed into this situation is also of concern here, with the influence of incongruent, distracting information forming the focus of the study. Indeed, the study looks closely at the particular set of relationships that exist between perceptions of being able to control achievement outcomes and the processing of task-related information, especially how controllability attributions serve to moderate the way in which WM processes task-relevant information in relation to situational inputs. However, to better understand the relationship between controllability and WM processes, we must begin by describing the cognitive aspects of attribution theory.

In Weiner's (1985, 1986) attribution theory of achievement motivation, the learner's perceptions of controllability largely determine the motivation to perform a learning task. Mainstream attributional theorists, such as Heider (1958) and Weiner (1985, 1986), have consistently emphasised the pivotal influence of controllability in the process of attributing causation, and empirical evidence supports the role of controllability as this functional motivator (Anderson, 1991; Pittman & D'Agostino, 1985; Taylor & Brown, 1988; Wortman, Panciera, Shusterman, & Hibscher, 1976). Moreover, research dealing with the notion of controllability has generated a variety of productive theoretical constructs (for a review, see Gilbert, Fiske, & Lindzey, 1998). Weiner himself (1974, 1980) distinguished two basic types of controllability, external (entity) and internal (incremental), to distinguish how the learner views control over the learning process. To this basic dichotomy, Weiner (1985, 1986) added specific attributional elements relating to controllability (luck, task difficulty, ability, effort), which could be used to further distinguish the level of perceived controllability over an achievement outcome. These elements pertain to learner motivation in that they specifically relate to the attributional dimensions of locus and stability in a predictable and consistent manner, as depicted in Table 1.

Table 1: An overview of Weiner's (1985, 1986) attributional elements and their relationship to the dimensions of locus and stability

		Locus Dimension	
		Internal	*External*
Stability Dimension	*Stable*	Ability	Task Difficulty
	Unstable	Effort	Luck

Controllability and attributional style

In the pattern of corresponding influences found in table 1, a consistent set of relationships exists between causal dimensions, attributional elements, and perceived controllability, the aspect of the theory germane to this study. The important point of this attributional model is that it suggests the learner will selectively attend to, as well as inhibit, task-related information according to the type of controllability information perceived as causal to the situation. Therefore, in terms of an initial understanding of the relationship between attributions and information processing, it is posited that perceived situational controllability (herein nominated *state controllability*) largely determines the selective encoding of salient task-relevant information. In addition however, it is also hypothesised that state controllability is itself moderated by an underlying, more stable factor also related to perceived controllability (herein nominated *trait controllability*). The notion of trait controllability, similar to the idea of a personality factor, is important to this study as an additional factor in the attributional model of learning, because it is perceived to influence the way in which situational cause and effect relationships are attributed. Its relationship to information processing stems from research into what is known as *attributional style*.

In attribution theory, the term attributional style is used to explain why people exhibit consistent differences in the types of attributions they make during causal reasoning (Abramson, Seligman, & Teasdale, 1978; Fiske & Taylor, 1991; Jones & Nisbett, 1972; Peterson & Villanova, 1988; Weiner, 1985). Although the concept of attributional style is often contested in terms of how it might be interpreted (Anderson, Jennings, & Arnoult, 1988; Sweeney, Anderson, & Bailey, 1986), it is nonetheless widely accepted as a stable aspect of personality (Bruder-Mattson & Hovanitz, 1990; Fiske & Taylor, 1991; Ostell & Divers, 1987). The notion of trait controllability adopted here is similar to the idea of attributional style, but conceived more in terms of the cognitive-developmental aspects of personality (C/F Thompson, Kaslow, Weiss, & Nolen-Hoeksema, 1998). It rests upon the assumption that cognitive schemata pertaining to the control of environmental outcomes are constructed during development and, thereafter, provide cognitive templates for attributions relating to situational controllability. Conceptually therefore, trait controllability represents an underlying, stable pattern of attributing causation that constrains an individual's expectations concerning the ability to control a performance outcome, a sort of cognitive "controllability style".

Trait controllability can be operationalised via the correspondences that occur between the attributional dimensions and attributional elements. For example, item results of a standardised attributional questionnaire can be translated into their corresponding attributional elements (luck, task difficulty, ability, and effort), and these elements can then be assigned a quantitative value (e.g., luck = 1; task difficulty = 2; ability = 3; effort = 4). The assigned values can then be used to represent an individual's underlying controllability expectations (i.e., trait controllability), as a measure of his or her underlying beliefs concerning being able to control learning-task outcomes at the generalised level. In line with Weiner's (1986) model, the values are obtained by rank ordering the attributional elements according to the overall degree of controllability each element represents in relation to the attributional dimensions, as shown in Table 2.

Table 2: Ranked values of the attributional elements, taken from the degree of controllability represented in each element

		Locus Dimension	
		Internal	*External*
Stability Dimension	*Stable*	Ability = 3	Task Difficulty = 2
	Unstable	Effort = 4	Luck = 1

Importantly, from this causal taxonomy an index of controllability can then be created, in order to compare individual trait controllability profiles. To do this, the rank ordered values are applied to individual answers on a standardised attributional questionnaire, according to their appropriate correspondences. For example, a participant reports that situational difficulties were the primary cause in an attributional vignette. According to table 2, this selection corresponds to the attributional element of task difficulty and translates into an assigned value of 2. On the other hand, an attribution of the same cause by another participant, perhaps to the intelligence of the vignette actor, would correspond to the element of ability and would translate into a value of 3. In this manner, a quantifiable measure can be derived from the attributional information, which can then be used to represent an individual's underlying predisposition to attribute controllability information. Totalling and averaging this sort of attributional information establishes a quantifiable index, a numerical measure of the underlying controllability expectations for an individual, in effect, an index of trait controllability.

Figure 1 shows the controllability index constructed for participants in the current study. Note that for this distribution there was a mean index score of 62.8. This is an interesting find, because, if the four attributional elements are viewed along a continuum (with each element representing 25% of the overall continuum), this mean score approximates midpoint for the third element, ability (mathematically this would be 62.5). It is to be noted that ability is the element that Weiner (1974, 1980) used to make his original distinction between entity and incremental views of learning. In marking the cut-off point for assigning study participants to either a high or low controllability group for testing purposes, the importance of ability is thus highlighted by this index. For this reason, and in accordance with Weiner's original distinction, the mathematical midpoint of ability (62.5) was used in the current study to categorise study participants, that is, to assign them either a high or low trait controllability rating, on the basis of a pretest attributional style questionnaire they completed. The question remains as to just how high versus low-controllability types might differ in the way they process incongruent state controllability information. The study attempts to answer this question by suggesting that the integration of state controllability information is moderated differentially by high and low controllability types. To make this final link we look again to WM.

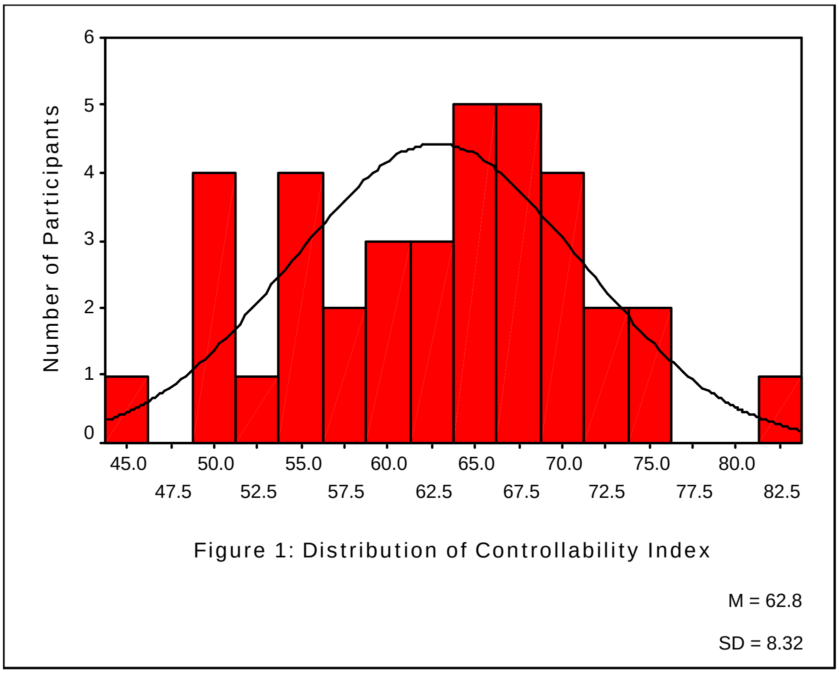

Figure 1: Distribution of Controllability Index

Controllability and WM

At the heart of this study lies the idea that attributional processes determine how WM resources are deployed during information processing, thereby influencing the learning process. Crucial aspects of WM are that it controls the processing of information during task performance and that it has an inherently limited processing capacity, making it ideal for testing the amount of information that is being actively processed during a cognitive performance task. A further assumption here is that interactions between trait controllability and state controllability moderate WM efficiency. This notion stems from Rotter's (1966) original concept that task performance relates to locus of control, a concept that has been widely used to identify patterns of performance and effort across a variety of behavioural domains (Abramson, Seligman, & Teasedale, 1978; Brown & Siegel, 1988; Friedrich, 1988; Harrison, Lewis, & Straka, 1984; Johnson & Kilmann, 1975; Lefcourt, 1982; Martinez, 1994; Weiner, 1974, 1980). In turn, several studies relate controllability to an information processing model of causal reasoning, and suggest that controllability attributions, via specific WM functions, affect the operation of selective attention (Bodner & Milculincer, 1998; Martinez, 1994; Webb, Worchel, & Brown, 1986).

Turning to selective attention, it appears that two complimentary WM mechanisms are thought to contribute to the way attentional processing operates: Maintaining selective focus on task-relevant information (Milliken, Joordens, Merikle, & Seiffert, 1998; Stadler & Hogan, 1996) and inhibiting distractions from task-irrelevant information (May, Kane, & Hasher, 1995; Passolunghi, Cornolki, & De Liberto, 1999; Wentura, 1999). Attention can thus be conceived as a selective process involved in perception, with an information processing bias interpreted as a failure of the WM executive to coordinate stimulus input with information held in long-term memory store, possibly due to the inability to make appropriate matches with existing cognitive schemata information. Importantly, the limited capacity of WM allows the prediction that attentional processing will respond differently to high-controllability attributional perceptions then to low-controllability perceptions, with low-controllability perceptions making a greater processing demand on WM. This is because low-controllability perceptions are associated with *spontaneous causal search* (Hastie, 1984; Moeller & Koeller, 1999; Wortman, Panciera, Shusterman, & Hibscher, 1976; Wong & Weiner, 1981; Weiner, 1986), an intensified effort to distinguish relevant information from irrelevant information during times of cognitive mismatch, in order to increase controllability. Spontaneous causal search requires that a greater number of information items be held in WM, while either partial schematic matches are made or restructuring strategies are implemented, to provide appropriate information categorisation in terms of source and familiarity. Because WM has limited capacity, any processing that activates spontaneous causal search should reduce the overall efficiency of processing in terms of the amount of information that is processed, speed of processing, and accuracy of the processing.

Study rationale

For these reasons a limited capacity WM construct is used here to measure processing efficiency under different types of controllability related feedback situations (C/F Anderson & Rigor, 1991). In addition, proposed differences in the types of moderating influences caused by interactions between high and low trait controllability can be indicated by differences in WM capacity that are specifically associated with positive versus negative task-achievement feedback. From this perspective, the influence of controllability perceptions on the way in which information is processed can be measured via the limitations of the WM system, to establish the existence of a moderating effect upon cognitive mechanisms that stems from attributional processes. Although attributional research has incorporated widespread use of both controllability and general memory measures (Devine, Hamilton, & Ostrom, 1994; Winter, Uleman, & Cunniff, 1985), the relationship between controllability and WM has attracted very little direct assessment apart from the work of Anderson & Rigor (1991), who looked at correlations between attributional style and memory recall. This study proposes to fill that gap and to show that an interactive relationship exists between stable aspects of personality, situational information processing, and the learning process.

Hypotheses

It is argued that an interdependent set of relationships exists between perceived situational controllability, underlying trait controllability, and information processing (as operationalised via WM function), and that these relationships affect the learning process. A series of five hypotheses are proposed to clarify and test this set of relationships:

First, due to the limited processing capacity of WM, it is predicted that high vs. low trait controllability types will respond differently to incongruent achievement-related information on a cognitive task that measures overall WM capacity. These differences will be measurable in terms of trait-related differences in processing amount, processing speed, and processing accuracy.

Second, it is predicted that high state controllability attributions will have no significant effect on measurable WM capacity for either trait types, relative to their nominal or baseline processing capacities (amount, speed, accuracy), on a cognitive task that measures overall WM capacity.

Third, it is predicted that low state controllability attributions will have a significant negative effect on measurable WM capacity for both trait types, lowering their capacities (amount, speed, accuracy) relative to nominal or baseline capacities, on a cognitive task that measures overall WM capacity.

Fourth, it is predicted that the negative effects of low state controllability attributions upon WM will be significantly greater for participants who rate higher in trait controllability than in participants who rate lower in trait controllability (as established by a pretest attributional questionnaire), because controllability expectations of the hi-trait types are more contradicted in this instance, requiring them to initiate spontaneous causal search in response to the contradictions.

Fifth, it is predicted that hi-trait types and lo-trait types will choose different types (entity/incremental) of attributional elements as the causal explanation for incongruent achievement-related information they receive during the cognitive task. Such nominations will be established by a posttest attributional questionnaire that asks participants to identify why they had performed as they did on the cognitive task. It is expected that the hi-traits will nominate entity (external) causes significantly more often, while the lo-traits will nominate incremental (internal) causes significantly more often.

METHOD

Participants

The participants (n = 37) comprised 22 females (58.3%) and 15 males (41.7%), ranging in age from 19-51 years (M = 31.53; SD = 9.96). Upon receipt of appropriate ethics approval, these participants received information sheets and informed consent forms and were told they were free to withdraw from this study at any time. This sample was drawn by convenience from the student population of a large regional university. It was heterogenous in terms of socioeconomic status and IQ, spanning long-term unemployed to current professionals, and with UAI scores ranging from 60 to 86. Using an alpha level of 0.05, a power analysis indicated that the sample size would detect only a large effect, controlling for type II errors with a statistical power of 0.27 (C/F Gravetter & Wallnau, 1996). However, the theoretical nature of the study made it important to perform an initial pilot investigation of the proposed model, because this model may have important implications for instructional design. For this reason the investigation continued.

Materials

Three different instruments were used to assess the influence of controllability on learning. Peterson and Villanova's (1988) *Attributional Style Questionnaire* (ASQ), a self-report measure based on that of Seligman, Abramson, Semmel, and VonBaeyer (1979), was used to measure attributional style, and hence to establish trait controllability ratings. The ASQ is widely used as a psychometric tool for tapping into perceived controllability (Peterson & Villanova, 1988; Seligman et al., 1979), and has moderately high levels of reliability and validity (Sweeny, Anderson, & Bailey, 1986).

The *operation-word span task* (the OSPAN, C/F Turner & Engle, 1989) was used as a measure of WM capacity. The OSPAN builds upon the work of Daneman and Carpenter (1980), who utilised concurrent processing to support a multi-component model of WM. It demonstrates high reliability estimates for internal consistency (.89 - .93, Cronbach's alpha; Turner and Engle, 1989, p. 134), and entails two distinct processing tasks: A secondary task that involves mentally solving arithmetic operations and making a value judgement as to whether the displayed operations are correct or wrong, and a primary task that involves memorising single words that appear with the operations and are later recalled at set intervals.

A posttest debriefing interview was used to establish which attributional element each participant chose as the causal explanation for her or his performance on the OSPAN. The interview asked how participants thought they had performed on the task (which involved false achievement-related information during one phase of the task), and also asked them to choose which one of the four attributional elements most closely represented the cause of this performance. This choice was considered an indication of perceived situational (state) controllability and was used to compare against the pretest (trait controllability) scores when looking for first order interactions as part of the data analyses performed.

Procedure

Once consent forms had been properly completed, each participant received a pretest attributional questionnaire, in order to establish a baseline trait controllability rating. The participant was then randomly scheduled for individual tests of WM capacity, using the

OSPAN. Manipulations of perceived controllability were carried out during phase 3 of this task, using either false-positive (FFC) or false-negative (FFI) achievement-related feedback. For the FFC (false-positive) group, this entailed providing computer generated feedback indicating they were recalling target information correctly almost all the time, regardless of their actual performance. In contrast, the FFI (false-negative) group received feedback indicating they were recalling target information incorrectly almost all the time, again regardless of their actual performance. At the end of the WM test, a debriefing session was held. Participants were interviewed to find out how they thought they had performed on the test and why. They were then asked to nominate one of the four attributional elements (luck, task difficulty, ability, effort) as the essential cause for this performance. The purpose of this interview was to elicit perceived situational controllability. All participants were then told of the false feedback phase of the task, and given their actual achievement outcomes.

RESULTS

There are four types of dependent information processing variables for this study: Recall level (overall WM capacity), percentage of total correct word recall (total recall), percentage of correct maths responses (accuracy), and processing speed (in terms of mean response time, or M_{rt}). To address the hypotheses for this study, a series of repeated measures 3-way ANOVAs were initially performed, utilising a mixed design (Trait Controllability x Feedback Condition x State Controllability). Each ANOVA tested these independent variables against each of the four dependent variables (recall level, total recall, accuracy, M_{rt}). Homogeneity assumptions were met, with both Box's M and Levene's tests being nonsignificant. Table 3 provides an overview of the participants in terms of age, false-feedback type, trait controllability, and state controllability.

Table 3: Summary of participant distribution by measures

Measure		Distribution
Age (in years)		
	M	31.7
	SD	9.6
	Range	19 - 51
Feedback Type:		
	FFC	20
	FFI	17
Trait Controllability:		
	Hi	19
	Lo	18
Perceived Experimental Control:		
	Luck	4
	Difficulty	9
	Ability	16
	Effort	8

No significant interaction between trait, feedback, experimental control, and recall level was found in this sample (F<1). However, significant first order interactions were obtained for total recall (phase x feedback x trait, F [2, 24] = 4.60, $p < 0.02$, $\eta^2 = 0.28$), as well as main effects for recall level (for both baseline and feedback by phase, F [1, 25] = 8.98, $p < 0.006$, $\eta^2 = 0.26$), and significant contrasts for some of the dependent variables (recall level*:* involving both baseline and feedback, F [1, 25] = 15.17, $p < 0.001$, $\eta^2 = 0.38$; feedback and recovery, F [1, 25] = 24.16, $p <$ 0.000, $\eta^2 = 0.49$; and word recall, involving contrasts between phase x feedback x trait, F [2, 24] = 4.60, $p < 0.02$, $\eta^2 = 0.28$). With such a small sample size, it was thought that the series of significant first order, main effect, and contrast findings were especially noteworthy, and worth exploring further.

Total recall

Looking at first order interactions for total recall, a significant interaction was noted for phase x feedback x trait, F (2, 24) = 4.60, $p < 0.02$, $\eta^2 = 0.28$. A trend also appears for phase x feedback x experimental control, F (4, 48) = 2.35, $p = 0.068$. As well, a direction appears to be developing for phase x trait x experimental control, F (4, 48) = 3.64, $p = 0.11$. Inspection of pairwise contrasts for the significant interaction phase x feedback x trait highlighted the way the two trait groups responded quite differently to positive vs. negative feedback on the WM test (Table 4). Whereas both trait groups recorded elevated recall under the false-correct feedback condition (FFC) and depressed recall under the false-incorrect condition (FFI), differences across phases for the hi-trait group in the FFI condition still evidenced a measure of progressive learning. This group progressively increased recall from baseline through recovery in spite of the depressed recall during phase 3 of the test. In contrast the lo-trait group evidenced a dissimilar trend, where overall recall from baseline to recovery remained static under the FFI condition. This discrepancy might reflect the internalising tendency of hi-trait types in that they are predisposed to attribute performance to internal factors and, hence, are more sensitive to negative feedback than lo-trait individuals. That is, perhaps the internalising tendency of the hi-trait types drives them more consistently to depend on effort as the basis for overcoming low achievement feedback information.

Table 4: Contrasts for trait controllability and feedback condition by phase

Feedback Type	Trait Group	Baseline	Phases Feedback	Veridical
FFC	Lo	60.41	76.41	69.33
	Hi	74.60	81.66	78.57
FFI	Lo	79.44	58.03	80.77
	Hi	81.95	60.30	80.48

Under these circumstances, if the hi-traits are displaying an internalising tendency, then sub-effects might be noticeable for the observed trends. Inspection of total recall for the phase x feedback x experimental control interaction (Table 5) suggests that participants who perceived experimental control in terms of internal elements (effort & ability) for the FFC condition recorded higher total recall across all three phases of the WM test than those perceiving experimental control in terms of external elements (luck & task difficulty). For the FFI condition, it was almost the reverse, with participants who perceived experimental control in terms of external elements recording highest total recall (although little difference is noticeable for recall in the recovery phase for this group).

Table 5: Mean total recall across test phases by feedback and experimental control

Feedback Type	Experimental Control	Baseline	Phases Feedback	Veridical
FFC	Luck	59.43	76.63	69.43
	Difficulty	54.80	73.80	61.9
	Ability	69.22	79.42	78.84
	Effort	77.76	83.28	76.12
FFI	Luck	83.30	68.30	88.90
	Difficulty	81.45	57.31	85.43
	Ability	79.99	56.23	85.20
	Effort	79.98	59.98	83.03

The possibility of a directional interaction between phase x experimental control x trait lends some support to a suggestion that the negative task-relevant feedback being presented for the FFI condition during phase 3 of the test may be masking a progressive learning effect. Inspection of the contrasts for this interaction (see Table 6) shows a significant difference between this false feedback condition and phase 4, in which a return to veridical feedback was resumed, F (2, 25) = 7.23, $p < 0.003$, $\eta^2 = 0.37$. This sub-effect suggested that lo-trait types are performing best under the false feedback condition when they choose luck as the causal element responsible for their performance and lowest when effort is chosen as the causal basis for performance. On the other hand, hi-trait individuals performed best under the false feedback condition when they perceived effort as the basis for their control over performance and poorest when experimental control was perceived in terms of luck. This oppositional pattern for performance is highly noticeable in the small sample used for this study. It underscores a primary proposal of the study, that individuals develop patterns in the way they attribute causation relating to task performance, and that these patterns then moderate the type of controllability cognitions that determine ongoing outcome expectations. Thus, in support of Weiner's (1974, 1980) basic premise, the hi-trait group tended to internalise successful performance and externalise failure, and the lo-traits group tended to internalise failure and externalise success. Figure 2 highlights this trend in terms of the types of causal elements nominated under the false feedback condition by these two groups during the posttest interview.

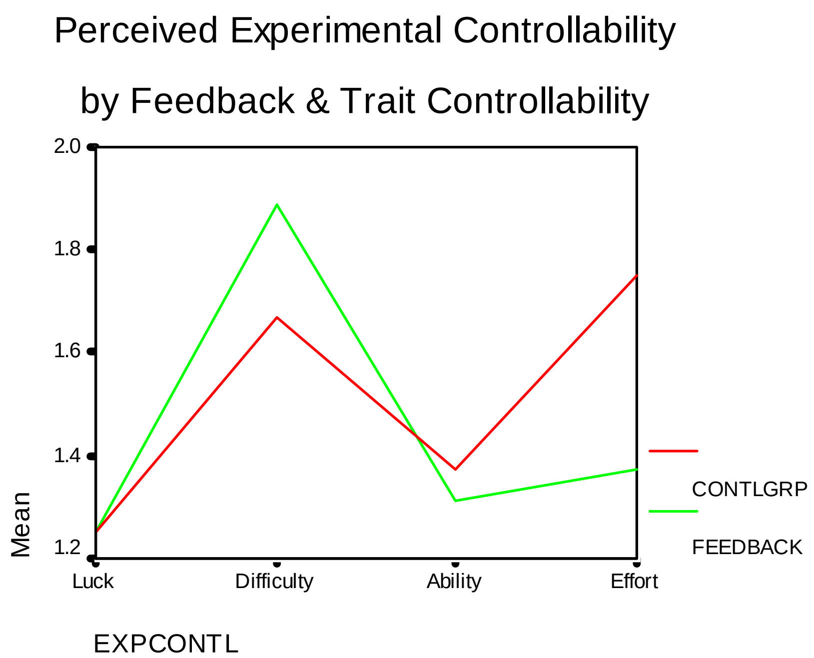

Figure 2: Directional interaction between phase x experimental control x trait

Table 6: Contrasts between false feedback and veridical feedback phases for trait controllability and perceived experimental control

Trait	Experimental Control	Phases Feedback	Veridical
Lo	Luck	76.63	69.43
	Effort	56.65	76.05
Hi	Effort	73.29	83.06
	Luck	68.30	88.90

For second order interactions, a highly significant interaction is to be noted for total recall across the 3 test phases by feedback condition, F (2, 24) = 45.85, $p < 0.000$, $\eta^2 = 0.79$. Overall mean recall was larger for the FFI feedback type than for the FFC type. Yet, as Table 7 shows, the differences between recall across test phases was positive and marginal for the FFC condition (Tukey's HSD = 0.17) but negative and extreme for the FFI condition (Tukey's HSD = 0.01). This finding is in accordance with the first prediction that little difference in measurable WM function would be evidenced for the FFC condition but that a significant decrease in WM function would accompany the FFI condition. Superficially, it seems obvious that receiving feedback conflicting with an outcome expectation is going to be more distracting than feedback supporting the idea that one is in control of an outcome. Yet this effect is nested inside the first order effects for total recall relating to interactions between trait and experimental controllability, a fact allowing this finding to be interpreted more in line with the model that predicted it.

Table 7: Mean Total Recall across test phases by feedback condition

Feedback Type	Baseline	Phases Feedback	Veridical
FFC	66.09	78.51	73.03
FFI	80.88	59.33	85.17

Recall level (WM capacity)

This ANOVA addressed the impact of trait controllability, feedback type, and perceived experimental controllability upon mean recall level (as a measure of overall WM capacity) across phases (see Table 8).

Table 8. Summary of mean phase recall level by trait controllability, feedback condition, and perceived experimental controllability

Trait Group	Feedback Type	Baseline	Phases Feedback	Veridical	Experimental Control
Low	FFC	1.50	2.26	2.06	Ability (6) Luck (3) Task Difficulty (1)
	FFI	1.83	1.70	2.45	Ability (4) Effort (2) Task Difficulty (2)
High	FFC	1.69	2.23	2.19	Effort (5) Ability (5)
	FFI	2.62	1.92	2.88	Task Difficulty (6) Luck (1) Ability (1) Effort (1)
	(Means for each Phase)	1.91	2.03	2.40	

Initially, it appeared that trait controllability had little effect on how recall level occurred across the three phases of the OSPAN task itself, a finding not supportive of predicted study outcomes. However, because of the small sample size and the possibility that a lack of power is responsible for these findings, a closer look at sub-effects for any trends in this direction was undertaken. Inspection of orthogonal contrasts involving only phases 1 and 2 of the test suggested that a trend might be developing between phase and trait, F (1, 33) = 3.14, p = 0.08, Tukey's HSD = 0.59. Table 9 suggests the potential nature of this tentative trend. Note that lo-trait participants progressively increased overall recall level between baseline, feedback, and recovery, whereas high controllability participants decreased recall level between baseline and feedback and then regained lost ground during the recovery phase.

Table 9: Contrasts between mean recall level for high versus low trait controllability by phase.

Trait	Baseline	Phase Feedback	Veridical
Low	1.66	1.98	2.26
High	2.16	2.07	2.54

Similar to total recall, what might be occurring is that hi-trait individuals are more prone to internalise situational controllability and are, therefore, less susceptible to initial test anxiety in performance situations (i.e., hi-traits are more motivated to "perform" than lo-traits). If this is true, then the interaction between phase and feedback type should show significant differences between the ways these two types performed.

Inspection of the phase x feedback interaction did reveal a significant relationship, F (2, 66) = 14.08, p < 0.001, η^2 = 0.32. Repeated contrasts (see Table 10) also showed a significant interaction, involving baseline and feedback again, F (1, 25) = 15.17, p < 0.001, η^2 = 0.38, and also a significant interaction between feedback and recovery, F (1, 25) = 24.16, p < 0.000, η^2 = 0.49. These findings supported the fourth hypothesis that the influence of low-controllability would be more noticeable in hi-trait types than in lo-traits. These results suggest that the cognitive-attributional model being tested has some merit in terms of its concept of trait controllability.

Table 10: Contrasts between mean recall level for "correct" versus "wrong" feedback by phase

Trait	Baseline	Phase Feedback	Veridical
FFC	1.60	2.24	2.13
FFI	2.23	1.82	2.67

For main effects for recall level, a significant contrast was also revealed between baseline and feedback for phase itself, F (1, 25) = 8.98, p < 0.006, η^2 = 0.26. If the trend noted earlier is followed, this effect could be due to the way individuals with higher trait controllability seemed to react more to the "wrong" feedback in phase 3 than did individuals with low trait controllability. The strong trend involving trait controllability, F (1, 33) = 3.80, p = 0.06, supports this interpretation, and suggests that negative task-relevant feedback has a stronger negative impact on hi-trait individuals than lo-trait types.

Accuracy

In terms of accuracy of response to the arithmetic operations on the WM test, the only significant interaction found was a first order interaction for phase x feedback x trait, F (2,24) = 6.92, $p < 0.004$, $\eta^2 =0.37$. Again, this suggests that the most important aspect of processing the task-relevant information, for both groups, was the way in which their underlying controllability style was interacting with the type of achievement feedback information they were receiving.

Mean response times (M_{rt})

With respect to the times recorded between the presentation of operation-word strings on the WM test and the actual pushing of a response button, only a possible trend was noted for the first order interaction phase x trait x experimental control, F (4, 48) = 2,24, $p = 0.079$). However contrasts revealed no significant sub-effects for this variable.

DISCUSSION

The purpose of this study was to test an expanded, cognitive-attributional model of learning in which the role of controllability as a moderator of information processing was examined. From this perspective, the investigation sought to determine whether feedback that contravened the trait type of the learner would influence cognitive performance. Although the small sample size used here has made it difficult to measure and clarify these proposed relationships definitively, the findings nonetheless offer tentative support to the idea that an expanded attributional model of learning can offer greater predictability to instructional designers wishing to enhance the learning environment.

Findings important to instructional design include the way in which trait controllability appears to moderate the salience of achievement-related information differentially for high versus low trait types, when their underlying controllability expectations are contradicted. This moderating effect can be inferred from the results relating to both recall level and total recall. For recall level, the interaction between phase and feedback was supported by a trend in which hi-traits seemed more susceptible to negative feedback than were lo-traits. A similar but significant interaction occurred for total recall, including trait in the interaction itself. Contrasts also showed occurrence of sub-effects for the interaction phase x feedback x experimental control. What seemed to be happening for both level and total recall was that hi-traits were internalising success and externalising failure, while lo-traits were externalising success and internalising failure. Hi-traits performed better initially, perhaps due to lower anxiety based on the expectation that they could control performance outcome. When faced with negative feedback however, hi-traits lost the ability to maintain momentum and fell behind in terms of progressive learning effects. It is to be noted that this phase change offers general support for Weiner's (1985, 1986) attribution model. However, here it involves interactions concerning both trait and experimental control, which shows that this effect can occur quite selectively, and, therefore, needs to be considered in a less generalised manner.

Perhaps the interactions occurring between feedback and experimental control across the performance task were masking a progressive learning effect, based on trait type. If so, then this also represents an important consideration for instructional designers. Causal reasoning, as evidenced here, seemed to be selectively directed at salient features of the learning environment that reinforced the underlying trait controllability orientation for each of the two groups. It may be that lo-traits were initially externalised in terms of success outcome expectations and, therefore, less distracted by "wrong" feedback during the feedback phase because they generally attributed such outcomes to causes outside their control. This also means they would be less motivated to increase effort when outcome expectations were not met. Hi-traits, on the other hand, would be more distracted and have a stronger association between outcome expectation and internal causation. They would be more motivated to increase effort when expectations are contravened. When false feedback continued to indicate a failure outcome however, they seemed to more naturally feel confused, perhaps overwhelmed, and to externalise the causes for their failure.

This may represent a type of trait reversal, and suggest that lo-traits possess an inherent schematic model of causation that allows greater mismatch between input information and existing knowledge. If controllability is generally perceived as due to external sources, then causation can be attributed in a more abstract and less urgent manner. Hi-traits, according to this speculation, have developed causal schemata in which ability and effort form the primary causes for performance outcomes. Two things might be happening for such types that would not normally happen to lo-traits. First, when outcome expectations do not match with existing knowledge, hi-traits are more driven to engage in intensive causal search, to locate a plausible causal explanation. This makes an increased processing load on limited WM resources, and decreases the efficiency by which the learning can occur. Second, they also experience an imperative to reconcile the discrepancy between expected trait controllability (from schematic knowledge) and unexpected feedback (from achievement feedback), even in the absence of affordable causation. This imperative biases the way information is to be encoded, making it harder to assure efficient functioning of attentional focus and cognitive inhibitory mechanisms, that is, it creates greater informational mismatch and thus leads to a decrease in processing accuracy.

Altogether, three of the five hypotheses relating to this study have received some measure of support. First, a difference was observable in the way individuals processed information in response to positive vs. negative achievement feedback. Second, this difference was most noticeable for the lo-trait types. Third, these perceptions were further moderated by the underlying controllability expectations inherent in the attributional style of an individual. These results, although tentative, nevertheless offer support for the existence of a stable, underlying factor (trait controllability), and for the moderating role of this factor in the way information is processed during a progressive learning task.

Implications

These findings have implications for learning because they indicate that targeting the learner's underlying controllability style will lead to more efficient information processing. One application of these results may be to consider how attributional motivation can be applied to differences between learners who work at a surface level of learning versus at a deeper level of learning. Perhaps when considering the cognitive style of a learner, her or his attributional style should also be considered as an important factor. Cognition is holistic and interactive. To design instructional approaches that cater for the widest possible distribution of individual differences, it may well be that educators need to organise the instruction around strategies that attempt to incorporate achievement related information within the parameters of a student's underlying attributional style. Good teaching always involves developing a relationship with students, and eliciting attributional information is relatively easy within the context of this sort of relationship. According to the current findings, this may well be an effective way to increase the sort of self-regulated learning that drives on-task processing.

On the other hand, it may be said that this level of instructional understanding is only marginally necessary to the teacher wishing to facilitate classroom learning for the "average" student. Yet when we turn to the area of special needs education it becomes immediately applicable, where a student's individual level of needs is taken into account for the purpose of designing and implementing an individual education program (IEP) or individual learning plan (ILP). Indeed, one of the primary objectives of special education is to adjust the classroom environment and curriculum to meet the abilities of students with special needs. A related objective is to promote student self-esteem. Students nominated behaviour disordered or emotionally disturbed often have very low self-esteem, which has severe and pervasive effects on the way they behave and the amount of responsibility they will accept. Students with low self-esteem will be seen, when compared to other students, to be more depressed, anxious, generally unhappy, and highly reactive to criticism. An important finding for the special education teacher, therefore, is that students who feel this way about themselves are likely processing information in a manner that biases their interpretation of instructional information.

Thus, special education designers need to develop a model for biased attributions that takes into account the crucial role of controllability in selective information processing.

Although further, large scale research is needed to flesh out these ideas, strategies to increase controllability would logically stem from design approaches seeking to encode both task-relevant and achievement information in a way that emphasises effort as the basis for achievement and self-knowledge (i.e., metacognitive awareness) as the basis for strategic problem solving. An emphasis on effort encourages students to internalise the learning, while metacognitive awareness helps them understand their own, individual level of self-efficacy. To add to this, important processing elements would need to be included in the instruction, targeting how to gain and maintain the initial attention of the learner, and then ensure that the purpose of the learning task is clear. Tying the task to prior learning is also important, as this offers a meaningful set of associations to the student and primes her or him for feelings of higher controllability over the learning situation (the use of analogy, metaphor, and simulations are excellent for this). Helping the student maintain attentional focus and appropriately inhibit distracting non-essential information can be facilitated by distinguishing essential information from the non-essential, and by seeking to demonstrate that a connection exists between the learning outcome and the student's efforts to control and sustain their attention span. The teacher should always focus on meaning for the learner, and, if necessary, break the learning objective into sub-tasks that present the information in a clear, scaffolded manner.

Conclusions

The philosophy of constructivism asserts that students learn best when they are actively involved in constructing their own knowledge through social, cognitive, and metacognitive activities. Two important aspects of constructive learning relative to this study are the way in which individuals create self-regulation from their underlying beliefs about controllability, and how such beliefs can act to moderate the way in which the individual then goes on to process task-relevant information. Many schools and curricula reflect a constructivist approach to programming and teaching, in which learning is presented in what are deemed developmentally appropriate stages. This study suggests that such programming also needs to consider the impact of important personality factors, such as attributional style or trait controllability.

Further research in this direction needs to explore various types of instructional strategies in relation to WM function, especially the sorts of cognitive tasks that may be unconsciously embedded within the instruction, to see if more specific interactions exist between strategic cognitive tasks and the learner's processing. It is also important to further address the question of whether progressive learning effects for a student can be masked by the interactions occurring between the teacher's feedback (situational controllability), and the student's underlying trait controllability, as viewed by the encoding of task-relevant information across a learning situation. A primary focus for such research would be to determine the degree to which a student's underlying level of expected controllability might influence how success or failure are externalised or internalised as the learning occurs. If, as the current study suggests, causal reasoning is selectively directed at salient features of the learning environment that reinforce the student's underlying level of trait controllability, then it may be that future teachers will need to familiarise themselves much more with a student's level of self-efficacy in order to facilitate higher learning outcomes. Many special needs students regularly go through a series of diagnostic and assessment tests prior to being funded for special education interventions. Therefore, the type of knowledge concerning this aspect of a student's profile can often be readily obtainable with little additional effort on the part of the supervising teacher or professional manager. In other cases this may require that specific measures be taken for this purpose. The results of this study suggest that in either case the learning needs of the student, that is, the central duty of care for educators, will be more fully informed.

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