OPERATIONALIZING AND TRACING
GOAL ORIENTATION AND LEARNING STRATEGY

by

Mingming Zhou
Master of Education, University of Leuven, 2004

DISSERTATION SUBMITTED IN PARTIAL FULFILLMENT OF
THE REQUIREMENTS FOR THE DEGREE OF

DOCTOR OF PHILOSOPHY

In the
Faculty of Education

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SIMON FRASER UNIVERSITY

Spring 2008

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APPROVAL

Name: Mingming Zhou
Degree: Doctor of Philosophy
Title of Thesis: Operationalizing and Tracing Goal Orientation and Learning Strategy

Examining Committee:

Chair: Maureen Hoskyn, Associate Professor

Philip Winne, Professor
Senior Supervisor

John Nesbit, Associate Professor
Committee Member

Lucy LeMare, Associate Professor
Internal/External Examiner

Eric M. Anderman, Professor, Ohio State University
External Examiner

Date Defended/Approved: April 22, 2008
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ABSTRACT

Recent years have witnessed a substantial body of research investigating motivational characteristics and their relationships with academic performance. In achievement situations, one variable that has received a great deal of attention is goal orientation. Following the observation of a gap in the way motivational constructs (e.g., achievement goal orientation) are operationally defined, I suggest alternative methods, called traces, which can make these implicit constructs visible and measurable. Using trace methods, learners' use of cognitive tools in a multimedia software environment (gStudy) reflects their goal orientations on the fly.

This fine-grained trace data was analyzed with data mining techniques to address several issues in research. First, this study provided evidence that students' perceived goal orientation did not accord with the behavioural traces of goals they pursued. Nor did self-reports predict test performance as well as trace data. Further, students high in need for cognition demonstrated better academic performance than those low in need for cognition, yet need for cognition did not interact with goal orientations reflected by traces as expected in predicting achievement.

When comparing high-achievers' versus low-achievers' learning activities, no differences were observed between the two groups in terms of self-reports except for need for cognition where high-achievers scoring higher. In contrast,
high-achievers exhibited significantly more frequent use of tools, and studied longer. The learning patterns identified in this sample, as shown by trace data, proved the existence of situational fluctuations of goal orientation within a single study session. Contrary to theory, a rigid pattern of studying that reflects mastery-approach goals does not assure higher achievement. A studying pattern marked by shifting between mastery-approach and performance-approach goals yielded the most positive achievement profile. Future research can gain substantially by merging trace methodologies with other means for gathering data about motivation and learning.

**Keywords:** Achievement Goals, Learning Strategy, Tracing Methodology

**Subject Terms:** Motivation, Academic Performance, Learning Strategy
To My Dearest Mom and Dad
ACKNOWLEDGEMENTS

A journey is easier when you travel together. This thesis is the result of three and half years of work whereby I have been accompanied and supported by many people.

I am deeply indebted to my senior supervisor, Dr. Philip Winne, for his supervision and guidance from the very early stage of this research as well as giving me extraordinary experiences throughout the work. He provided me unflinching encouragement and support in various ways. His truly scientific intuition has made him a constant oasis of ideas and passions in educational science, which has exceptionally inspired and enriched my growth as a graduate.

I would also like to thank Dr. John Nesbit who was always available when I needed his advice. His originality has triggered and nourished my intellectual maturity in a way that I will benefit from, for a long time to come. I appreciated his help on solving the methodological problems that occurred over time. The Learning Kit group also substantially contributed to the development of this work. Without you all, this work would not be possible.

Lastly, a special thanks goes to Yabo-Arber Xu, for his excellent technical support, which was far beyond duty. Without his assistance, the state-of-the-art method would have entirely vanished from this research. Thank you for your support all the way!
# TABLE OF CONTENTS

Approval ........................................................................................................ ii
Abstract ........................................................................................................ iii
Dedication ...................................................................................................... v
Acknowledgements ...................................................................................... vi
Table of Contents ........................................................................................ vii
List of Figures ................................................................................................ ix
List of Tables .................................................................................................. x
Glossary ......................................................................................................... xi

Chapter 1: DESCRIPTION OF THE PROBLEM .............................................. 1

Chapter 2: PHILOSOPHY OF GOAL ORIENTATION OPERATIONALIZATION .. 7
  Would operationalization help? ................................................................. 7
  Issues with self-reports ........................................................................ 10
    Memory distortion ............................................................................. 11
    Now-that-you-mention-it effect ......................................................... 13
    Contextual invariance ...................................................................... 15
    Individual interpretations ................................................................. 18
    Static measures vs. dynamic learning ............................................. 18
  Summary ............................................................................................... 20

Chapter 3: METHODOLOGY OF OPERATIONALIZING ACHIEVEMENT GOAL ORIENTATIONS .................................................................................. 23
  Goal orientation and intrinsic / extrinsic motivation ................................ 23
  Behavioural measures of intrinsic / extrinsic motivation .................... 24
  Goal-tracing methodology in multimedia learning environments ........ 26
    Stage I: Developing tags and traces of goal orientation .................. 27
    Stage II: Analyzing trace data to link motivated actions to goals 
    orientations ....................................................................................... 32

Chapter 4: PILOT STUDY ............................................................................ 38
  Participants ........................................................................................... 39
  Procedure .............................................................................................. 39
  Results .................................................................................................. 41
  Discussion ............................................................................................. 45
LIST OF FIGURES

Figure 1 A screenshot of gStudy user interface .........................................................29
Figure 2 A snapshot of gStudy log files .................................................................33
Figure 3 A screenshot of Action Library user interface ........................................34
Figure 4 A snapshot of the parsing output — action list ....................................35
Figure 5 A snapshot of the parsing output — action statistics .............................35
Figure 6 Graphic representation of four groups by self-reported goal orientations .................................................................42
Figure 7 Average frequency counts of label choices among four groups ..........45
Figure 8 A sequential pattern exemplification .......................................................83
Figure 9 The adapted shift-reduce parser output screenshot ...............................84
Figure 10 Overall sequential patterns graph .........................................................87
Figure 11 High-achievers’ vs low-achievers’ selection of content for label application .........................................................................................93
LIST OF TABLES

Table 1  Labels Representing Four Types of Goal Orientations ..........................41
Table 2  Correlation Coefficients of Goal Orientations with Label Choices 
(N = 21) .................................................................................................................42
Table 3  Means and Standard Deviations Obtained by Four Groups and F 
Value for Each of the Dependent Variables .......................................................43
Table 4  Tags for Labels and Hyperlinks Representing Four Goal 
Orientations ...........................................................................................................46
Table 5  Properties of Self-Reported Goal Orientation Variables (N = 103) ......54
Table 6  Properties of Learning Activity Variables (N = 95) ...............................55
Table 7  Correlations among Self-reports and Trace Data of Goal 
Orientations (N = 95) ...........................................................................................57
Table 8  Correlations between Learning Activity Measures and Goal 
Orientation Trace ....................................................................................................61
Table 9  Dimensions of Learning Activity and Goal Orientation Trace 
Measures ..................................................................................................................63
Table 10 Correlations between Self-Reports, Goal Orientation Trace, 
Learning Activities and Test Performance (N = 95) .............................................67
Table 11 Relationships among Need for Cognition, Goal Orientation Trace 
and Achievement ..................................................................................................73
Table 12 Summary of Hierarchical Regression Predicting Achievement 
with Need for Cognition (NFC), Mastery-Approach Goals (MAP), 
and the NFC x MAP Interaction ........................................................................74
Table 13 Summary of Hierarchical Regression Predicting Achievement 
with Need for Cognition (NFC), Performance-Approach Goals 
(PAP), and the NFC x PAP Interaction .................................................................75
Table 14 High-Achievers vs. Lower-Achievers in Test Performance, Self-
reported Goal Orientations, Need for Cognition and Learning 
Activity Variables ..................................................................................................92
Table 15 Learning Sequential Patterns in High-Achievers and Low-
Achievers .................................................................................................................96
## GLOSSARY

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
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</thead>
<tbody>
<tr>
<td>Action</td>
<td>An action consisting of a series of events.</td>
</tr>
<tr>
<td>Event</td>
<td>A record in a data file that indicates something has happened, such as a keystroke or mouse click.</td>
</tr>
<tr>
<td>Log (Trace)</td>
<td>A transcript containing the events during students' interaction with the software and the time when that event occurs.</td>
</tr>
<tr>
<td>Mining</td>
<td>Extracting useful information from a particular data set</td>
</tr>
<tr>
<td>Parsing</td>
<td>The process of analyzing a sequence of events to determine its structure with respect to a given grammar.</td>
</tr>
<tr>
<td>Pattern</td>
<td>A subsequence is deemed as a pattern if it occurs more often than a specified threshold (specified as a proportion of the sequences)</td>
</tr>
<tr>
<td>Sequence</td>
<td>An ordered list of events or actions.</td>
</tr>
<tr>
<td>Shift-reduce parsing</td>
<td>Also known as bottom-up parsing. It is a strategy for analyzing unknown data relationships that attempts to identify the most fundamental units first, and then to infer higher-order structures from them. It attempts to build trees upward toward the start symbol.</td>
</tr>
<tr>
<td>Subsequence</td>
<td>A new sequence which is formed from the original sequence by deleting some of the elements without disturbing the relative positions of the remaining elements.</td>
</tr>
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CHAPTER 1: DESCRIPTION OF THE PROBLEM

Motivation is one of the most important factors that affects learning in any educational environment (Maehr, 1984), accounting for approximately 20% of the variance in achievement and about 29% of the variance in transfer of knowledge (Colquitt, LePine, & Noe, 2000). Recent years have witnessed a substantial body of research investigating motivational characteristics and their relationships with performance. Multiple and contingent factors have been acknowledged to affect learning of highly complex knowledge – e.g., learner dynamics and cognitive processing. One variable that has received a great deal of attention in achievement situations is goal orientation. Originating in the educational psychology literature to explain differences in student learning behaviour (e.g., Dweck, 1975; Eison, 1979; Nicholls, 1975), goal orientations have important implications for learning, motivation, and performance across age groups and settings. According to goal orientation theories, goals manifest as different ways of approaching, engaging, and responding to achievement-related activities (Ames, 1992; Dweck & Leggett, 1988). Research in this field is prevalent and quite consistently shows that achievement beliefs and goals predict a wide array of student outcomes (Weinstein, 2004). Various researchers contrast apparently different types of achievement goals in studies examining relationships among goals and cognitive, affective and behavioral outcomes. Results are mixed (for
reviews, see Ames, 1992; Urdan, 1997). Possible reasons for inconsistencies in this literature are threefold.

The first possible reason for inconsistency in findings is lack of clarity about the psychological nature of this construct. DeShon and Gillespie (2005) claim there is no common definition of goal orientation, so researchers refer to very different processes by the same term. Such variations about what goal orientation is and how it should be measured undermine a stable foundation for research involving goal orientation and its role as an antecedent, moderating variable, and consequence.

One example is the debate concerning whether goal orientation is a trait-like or state-like disposition. According to the former school of thought, goal orientation has been treated as a personality variable that contributes to individual differences in behavior and that is relatively invariant over time and across performance contexts (e.g., Bell & Kozlowski, 2002; Colquitt & Simmering, 1998). From the latter perspective, although individuals may possess dispositional goal orientations that provide a “default” orientation across various settings, it is also likely that individuals may develop different states of goal orientation in response to particular and immediately present characteristics of the performance environment they experience (e.g., Button, Mathieu, & Zajac, 1996; Elliot & Church, 1997; Mangos & Steele-Johnson, 2001; VandeWalle, Cron, & Slocum, 2001). The state-like conception is conceptually similar to the trait-like conceptualization regarding one’s goal preferences in an achievement situation; however, it is yoked to the task or context at hand (e.g., Stevens & Gist,
Goal orientation is also regarded in some cases as a *mental framework* consisting of a wide variety of beliefs, affects, goals, and cognitions that covary in a regular way in achievement contexts and result in achievement related behaviour (e.g., Ames & Archer, 1987; Farr, Hoffman, & Ringenbach, 1993; Strage, 1997). The representative examples of the mental framework definitional approach highlight that there is very little focus on the process of goal orientation and, instead, the term goal orientation is used as a catchall phrase to describe global patterns of how individuals perceive and respond to achievement situations. Perhaps the least frequent use of definition is the individual's *beliefs* or implicit theories of ability (e.g., Dweck & Leggett, 1988; Franken & Brown, 1995). Goal orientation, from this perspective, is thought of as following from an individual's beliefs or implicit theories concerning the malleability of ability.

Alternatively, the *goal-like* definition views goal orientation as the adoption and pursuit of specific goals in achievement contexts. Along this thread, goal orientations are sometimes denoted as the goals that are implicitly pursued by individuals while attempting to attain or achieve a certain level of performance (e.g., Breland & Donovan, 2005). In contrast to this “product” view, some researchers refer to it as an individual's orientation toward different types of goals in achievement situations (Dweck, 1986; Dweck & Leggett, 1988; Elliot & Harackiewicz, 1996; Middleton & Midgley, 1997; Nicholls, 1984). This definition directs attention to the goal-pursuing process in which individuals can either
choose to approach desired or avoid undesired outcomes (Elliot & McGregor, 2001). The achievement motive disposition was the central construct in this approach: the need for achievement (a tendency to approach success because one anticipates pride upon success) and the fear of failure (a tendency to avoid failure because one anticipates shame upon failure; Atkinson, 1957).

These conceptual ambiguities could partially account for some of the inconsistent empirical results regarding associations among goal orientation and achievement outcomes (e.g., Elliot & Thrash, 2005; Grant & Dweck, 2003). Evidently, our understanding of this construct and its relationships to other individual difference factors is limited and a more complete understanding is needed (Heintz & Steele-Johnson, 2004). In turn, this diversity in conceptualizations of goal orientation may be an obstacle to fruitful scientific research and theorizing.

The second reason for inconsistent results in studies involving goal orientation focuses on the assumption that more than one goal may be simultaneously operative (e.g., Bouffard, Boisvert, Vezeau, & Larouche, 1995; Meece, 1994; Pintrich & Garcia, 1991; Urdan, 1997), which affords some flexibility to adapt more efficaciously to various learning situations. For instance, performance goals are observed to inextricably link to mastery goals in that it is impossible to obtain positive judgments of ability without first achieving a relatively high level of task mastery in certain contexts (Wentzel, 1991). Although a student may be mainly concerned to master course content, he or she may enjoy showing more skill than others and report satisfaction for having
succeeded in doing so (Riveiro, Cabanach, & Arias, 2001). This helps in accounting for inconsistencies in recent empirical results wherein negative relations were found between performance-oriented and mastery-oriented goals in some studies and in others there were no relations or even positive relations (e.g., Valle, Cabanach, Núñez, Gonzalez-Pienda, Rodríguez, & Piñeiro, 2003). It also may account for conflicting findings regarding the impact of the same type of goals on learning processes and outcomes (e.g., Midgley, Kaplan, & Middleton, 2001).

Finally, despite methodological differences (e.g., samples, self-report inventories) across studies, and discounting the situation-specific nature of achievement goals (Elliot, 2005), these diverse findings suggest that the predictive validity of goal orientation measures is variable. According to widely regarded self-regulated learning models (e.g., Winne, 2001, 2005; Zimmerman, 2000), as a self-regulated learner approaches a given task, he recognizes features of the learning environment that affect chances of success. Once such features are recognised, they need to be interpreted and a choice made (e.g., a goal defined). The learner surveys expectancies (odds of success) and consequences relating to the goal(s) selected to accomplish. As the learning context components are of different kinds (e.g., cues in different locations of an article), learners have to regulate their study, including adjusting goals as well as modifying learning tactic, to be adaptive. To the extent researchers do not attend to this complex and possibly recursive process over the course of a single studying task may partially account for the inconsistent results.
All these plausible reasons point to the importance of investigating how learners engage in goal-directed activities. A key factor that supports the present investigation is to seek an accurate and reliable measure of learners' goals, as well as ensuing studying behaviour. In the current study, I addressed this problem using an "operational definition" (Blumer, 1940, p. 710) in which the meaning of a concept is directly linked to and informed by actions that generate the phenomenon as described in the concept.
CHAPTER 2: PHILOSOPHY OF GOAL ORIENTATION Operationalization

Would operationalization help?

Blumer (1940) claimed in his classic paper that concepts which are inconsistent and unclear introduce a gap between theory and empirical observation and likewise do not allow for rigorous deduction; hence, testing of the concept by empirical observations produces varied results and the revising of the concept is made difficult. Because of this difficulty in effective validation, "such concepts are conductive to speculation in the unfavourable sense of that term; the unsettled content of the concept encourages thinking to move along divergent directions without the benefits yielded by logical coherence" (p. 707-708).

Following his lead, I take it that the diversity in the conceptualization of goal orientation is an immediate obstacle to effective scientific research in contemporary motivational theorizing in psychology. The multiple definitions of goal orientation constitute an unstable foundation for research on the antecedents and consequences of the goal orientation construct (DeShon & Gillespi, 2005). Determining the effects of goal orientation in various settings only can make sense when we are clear about how this construct is conceptualized. Did researchers focus on identifying individuals who possess a particular orientation (trait-like), or who develop different states of goal orientation in...
response to the achievement contexts (state-like)? Did researchers manipulate the goals pursued by individuals (goals) or manipulate the beliefs or implicit theories held by individuals? Similar issues arise when attempting to apply existing goal orientation definitions to organization training practices. Is goal orientation a selection issue (trait), a climate issue (beliefs and norms), or a developmental issue that may be managed through appropriate goal setting and feedback processes? This divergence must be bridged if motivation research is to acquire the character of a scientific discipline or to yield knowledge that is scientific in nature.

Discarding prevailing concepts and taking a new stance to avoid concepts which display inconsistency is to turn away from the problems of the area. This pathway does not promise a solution to the dilemma. Judging from efforts taken in this direction, the same problem arises with reference to the new concepts. Nothing is gained by changing the designation or label. On the other hand, continuing to form and to use explanations built around concepts that involve too much variation is to merely perpetuate the problem. The goal framework continues to be plagued by unresolved conceptual ambiguity.

A proposed path toward resolving this problem has been presented under the heading of the method of “operational definition” (Blumer, 1940, p. 710; see also Borsboom, Mellenbergh & van Heerden, 2002). Operational definitions bind the meaning of a concept directly to actions that generate occurrences of that concept. This method, obviously, would confine the meaning of a concept to quantitative (at least nominal) and measurable data. It has the benefit of
generating precise content amenable to exacting empirical test (Borsboom et al., 2002). Such definitions are used as a follow up to a conceptual definition, in which the specific concept is defined as a measurable occurrence. A behaviourist psychologist might (operationally) embrace this method with open arms and recognize goal-directed behaviour as a series of observable actions in response to variations in stimuli, which a cognitively lenient theorist would say are connected with the goal (Gollwitzer, 1997).

However, as theoretical developments in the psychology of motivation have moved beyond explaining the choice of actions to the wilful control of actions (Gollwitzer, 1997), the metaphor that governs theorizing on human information processing has changed from the “cognitive miser” to the “flexible strategist” (Fiske & Taylor, 1991). Hence, operationalizing psychological constructs, such as goal orientation, requires a behavioural and social-cognitive view in conjunction. The point emphasized here is that behavior cannot occur in vacuum, nor can observations be considered independent a priori. The central factors in the situation are: What behaviour is to be observed? How does the observed behaviour corroborate the construct to be operationalized.

Goal orientation is quite often labelled as a mental activity that occurs in a person’s mind. It is as abstract as emotions in the sense that it is not something that can be measured or compared by a marker. Initial attempts to operationalize goal orientation took the form of responses to questionnaire items, probes in an interview, or content revealed in think aloud protocols by working from the common term and trying to identify it in different expressions (Kelley, 1992). To
date, a variety of self-reports instruments have been developed to measure goal orientation: Brett and VandeWalle, 1999; Button, Mathieu, and Zajac, 1996; Duda, 1989; Elliot and Church, 1997; Elliot and McGregor, 2001; Harackiewicz et al., 1997; Horvath, Scheu, and DeShon, 2001; Midgley et al., 2000; Nicholls, 1989; VandeWalle, 1997. This is congruent with Winne's (2004) observation that the overwhelming common methodological tool used to gather data about goals, motivation, and other self-referenced constructs is a self-report protocol.

**Issues with self-reports**

Recalling the foregoing discussion about inconsistent definitions of the concept, it should be noted that an omnibus instrument intended to measure a focal concept may (a) pick up what other investigators, pursuing particular causal hypotheses, may wish to exclude; (b) have items in common with scales measuring different concepts; and (c) lose validity through the effects of irrelevant causal factors on certain component measure. For example, in a measure of interpersonal attraction, items concerning the amount of time two persons spend together — a presumed consequence of attraction — may reflect opportunities rather than positivity of attitudes (Kelley, 1992). This is further evidenced by Smith, Duda, Allen and Hall's (2002) study which was to determine whether different goal orientation measures were assessing the same construct by attending to Marsh's (1994) warning about the “jingle” (scales with the same label assess similar constructs) and “jangle” (scales with different labels assess different constructs) fallacies that often befall questionnaires used in psychology. The results of two separate confirmatory factor analyses highlighted that,
although a degree of convergence emerged between the subscales labeled as tapping the same constructs across the instruments, very few were statistically strong – the amount of variance accounted for ranged from 1% to 36%. The researchers claimed that this unfortunate finding might be due to “differences in the operational definition proffered by the author of each measure, and the subsequent item content of the subscales” (p. 185).

Scholars have argued that self-report data are necessary but insufficient when researchers investigate relations among goals, motivations, beliefs, and affect on the one hand; and study tactics and learning strategies on the other hand (Winne & Perry, 2000; Winne, Jamieson-Noel, & Muis, 2002). In addition to frequently cited drawbacks of self-reports such as social desirable response, response styles, and motivated distortion, when researchers put the goals in the participants’ mouths, so to speak, several other potential problems arise.

**Memory distortion**

Tourangeau (1984) proposed that the respondent has to interpret and comprehend the question, retrieve relevant information from autobiographical memory, use heuristic and other decision-making processes to estimate an answer, and then formulate a response. As this and other information processing models indicate, answering survey questions is not a simple process but consists of various stages of complex cognitive processing (Murtagh, Addington-Hall, & Higginson, 2007). However, memory is subject to loss (forgetting), distortion (biased sampling of memories), and reconstruction during this cognitive processing. All three effects can undermine the accuracy and reliability of
responses. This is not to deny that a correlation is observed between sets of these responses and other variables but a challenge is raised as to what is correlating with those other variables.

There is abundant evidence that memory content can undergo systematic changes over time. Diverse paradigms have been developed to investigate changes that are either induced by experimental interventions (Loftus, 1975) or by the subject, such as reflecting memories of the past in accord with current self-perceptions (Ross, 1989). Past research (Thompson, 1985) has generally shown that retention is best for experiences that are affectively pleasant, intermediate for experiences that are unpleasant, and worst for experiences that are neutral. In an investigation of the accuracy of recalled grades in high school students (Bahrick, Hall, & Berger, 1996), the most startling finding pertains to differences in the accuracy of retention – recall accuracy monotonically declines from 89% for grades of A to 29% for grades of D, a reflection of the degree of pleasantness associated with higher achievement. In subsequent analyses, individuals who were more satisfied with their grades, more confident of their recall, or had a higher level of academic achievement were observed to be more accurate in recalling their grades. Because higher grades are affectively pleasant and associated with the satisfaction of achievement motive, this elevates rehearsals of the memory content and thus enhances retention (Rubin & Kozin, 1984).

Similarly, it would be predicted that when students were asked to recall their learning strategies, those approaches that are most effective (but not
always) and lead to impressive learning outcomes will be most likely recalled and reported. Data show that students tended to rate themselves very high on typical study strategies (e.g., frequently taking and studying class notes) and lowest on task preparation strategies (e.g., rereading notes and text in preparation for a test) (Garavalia & Gredler, 2002).

Further, learners are not very reliable observers of how they actually participate in events. Perhaps the most elementary question we can ask about this is whether humans really can remember/perceive things or experiences as they actually were. In a series of exploratory studies of calibration (e.g., Winne et al., 2000; Winne & Jamieson-Noel, 2002), researchers examined the match between students’ self-reports about study tactics and their actual use of tactics as traced by software. Students were variably biased in self-reporting their use of study tactics, reporting having planned a method for studying on average 29% more than traces indicated; and having reviewed figures 26% more than traces indicated. In contrast, others reported having set objectives for studying 32% less than traces indicated. Hence, caution should be taken when interpreting findings about study tactics when the data collected are students’ self reports. Predictions based on findings of such studies also should be tempered.

**Now-that-you-mention-it effect**

Asking students to respond to survey items may produce a “now-that-you-mention-it effect whereby students agree they want to do better than others when asked about it, but if they were not asked about it, they would rarely think in such terms” (Urdan & Mestas, 2006, p. 355). Some research suggests that when
students are not directly asked about mastery and performance goals, they tend to mention other concerns more often, such as avoiding trouble, avoiding work, and going to college (Lemos, 1996; Urdan, Kneisel, & Mason, 1999). Also, students report certain strategies are adopted only because they know or believe they are effective, not because they actually use those strategies to any great extent (Samuelstuen & Bråten, 2007). This effect differs from memory distortion in that it is not related to how well individuals can remember things that happened in the past; rather, probes or questions phrased according to the instrument designers' frame of thinking lead respondents to follow the guided questions, and in ways not necessarily coinciding with respondents' view. This deviation from the fact could lead to misleading interpretations.

A relevant example is Conway and Ross' (1984) study wherein students were randomly assigned to a study skills program or to join a waiting list for the program. Researchers also asked all the students to rate their current study skills before and after the program, and after the program they also asked all the students retrospectively to rate their study skills before the program had taken place. They found that students who had taken the program rated their study skills as having improved, but the main reason for this was that the retrospective ratings tended to denigrate their former skills. Their subsequent academic performance was actually no better than that of the students on the waiting list. Nonetheless, many of them continued to insist that the program had been beneficial despite having been advised to the contrary at their debriefing (Ross & Conway, 1986). These results indicate that under some circumstances students
do not provide valid and accurate accounts of their dispositions and capabilities and tend to reconstruct their autobiographical memories to fit an implicit yet invalid theory about personal change (Ross, 1989).

**Contextual invariance**

The third category of limitations to self-report measures concerns the task environment (context). While there certainly are several reasons to dampen one’s trust in students’ ability to access the content of long-term memory and make accurate generalizations about how they learn (Menon & Yorkston, 2000; Tourangeau, 2000; Winne et al., 2002), the most fundamental issue with most measures seems to be that they do not take the fact that students modify their strategic processing to fit different tasks and purposes into account (e.g., Bråten & Samuelstuen, 2004; Hadwin, Winne, Stockley, Nesbit, & Woszczyna, 2001).

Quite commonly, self-report data are generated with no reference to specific learning tasks or with reference to the large variety of activities students experience throughout an entire undergraduate course (e.g., Elliot & McGregor, 2001; Nicholls, 1989) wherein large contextual variance exists. In accord with contemporary views about learning as a situated activity, learners examine and judge features of their cognitive engagement in relation to a context (Perry & Winne, 2006), and the cognitive and motivational constructs in a context influence each other as well as being influenced by the social context (Pintrich, 2000b; 2000c). If a context (e.g., a set of task conditions) is not established by a self-report instrument’s protocol, there is no way to know what conditions respondents have in mind when they report their behaviors. Conditions are likely
to vary among respondents, creating problems for interpreting and generalizing their data.

Intuitively, goals can be understood as cognitive representations of what a student wants to achieve (Ford & Nichols, 1991) by applying strategies and tactics for learning (Pintrich & Garcia, 1991). Along with insights generated by analyses that separate these constructs and emphasize their individual contributions to learning behavior is an equally critical need to focus on their interdependence (Ainley, 1993). Maehr and Pintrich (1991) distinguished goal and strategy as the "how" and "why" of achievement behavior while emphasizing their "inherent unity" and complementary nature. In a similar vein, Ford and Nichols (1991) emphasized the essential interdependence and organization between goals and self-regulatory processes in their analysis of motivational patterns in learning. They represented "behavior episodes" as nested hierarchies within which layers of increasingly context-specific goals can be identified. As well, Wolters (1998) pointed out that learners regulate and monitor cognitive and motivational aspects during learning processes. This implies that both study tactic use (cognitive aspect) and achievement goals (motivational aspect) are responsive to the learning situation.

To investigate this hypothesis, Hadwin and colleagues (2001) developed a questionnaire that asked students to report the frequency with which they applied a range of study tactics, selected various study-related resources, and adopted goals in three distinct contexts within one course: reading for learning, completing a two-page essay assigned in the course, and studying for the
midterm examination. Students' responses were consistently subject to context effects in both level of and patterns among study tactics they applied, resources they used, and goals they selected for studying. As reflected in results of the researchers' principal-components analysis, students' constructions of their studying showed greater sensitivity and adaptation to context than theorists' representations of the dimensions of studying by the subscales that partition the questionnaires. When questionnaires do not guide students to consider specific contexts or when students are not provided opportunity to describe the particular context they have in mind when they respond to self-report items, interpretations of their responses may be inappropriately general (Hadwin, et al., 2001).

Bråten and Samuelstuen (2004) also observed that students adjusted their self-reported use of strategies according to three different reading situations: reading to discuss text content with others, reading to write a summary, and reading in preparation for a test. Zimmerman (1994) obtained similar findings in his study — responses to self-report items about study tactics, goal selection, and external resource use vary when study context varies. Unfortunately, very few of the extant questionnaires explicitly investigate situated goals within or across learning contexts. Such findings provide evidence that students' self-reports are context-specific and raise questions about using strategy measures that do not reflect context effects (Hadwin et al., 2001). If one prefers self-report methodology, using strategy questionnaires tailored to specific tasks or contexts may therefore be the first improvement to make.
Individual interpretations

Surveys obviously must provide wording for items when students attempt to fit their own perceptions to that wording, hence, variations in responses might reflect differences in individual perceptions about items, not necessarily the differences in the item content. With surveys, researchers typically define a terminology (such as goal orientations) for participants, asking them to indicate on a Likert-type scale their agreement with the mastery or performance goal items. Most self-report measures ask respondents to report qualities of their actions, such as frequency, difficulty, typicality, and usefulness, with respect to an unidentified aggregate of particular instances. Since it is unlikely learners store in memory a tally of the frequency with which they engage in particular activities, they rely on heuristics to estimate such properties of engagement (Perry & Winne, 2006). Items such as “I become very concerned if I did not perform well in the exam” will be defined differently according to the self-perception of students about what counts as “very concerned” and “perform well”. Similar issues arise when respondents are asked to choose from “sometimes” to “always”. With no additional questions for researchers to follow up on participant responses, it is likely that students vary in their interpretations of the same goal items (Urdan & Mestas, 2006).

Static measures vs. dynamic learning

Merely observing a gain in achievement is a logically insufficient basis for constructing a valid account about how knowledge is constructed through goal seeking activity (Borsboom, Mellenbergh, & van Heerden, 2004; Winne, 2006a).
Gaining knowledge of processes learners engage as they study content is essential to advance theory and inform designs for learning environments. Self-regulated learners are generally characterized as active learners with adaptive learning goals. They have a set of cognitive and metacognitive strategies to deploy and, when necessary, modify in response to shifting task demands (Butler & Winne, 1995; Pintrich & Garcia, 1991; Zimmerman, 1989). This self-regulated learning (SRL) process is dynamic, recursive and cyclic such that goals drive strategies and the outcomes of strategic engagement may lead to changes in goals.

Consider this example: A student set a goal to achieve a better mark on the next quiz and then began to study the chapter assigned this week. As he read further in the chapter, he found the topic quite interesting. This temporarily aroused his eagerness to explore. He suspended his usual memorization and note-taking tactics, methods chosen to meet the goal of raising quiz marks, and replaced these with more metacognitive activities, such as investigating Wikipedia and making annotations that linked his prior knowledge to what he was reading. After satisfying his curiosity, he returned to “normal” procedures to study in ways that he believed best for elevating his marks.

Shifts like these, I believe, are common. Yet, no survey instruments I have examined capture perceptions about them, nor can those instruments reflect the actual occurrence of those shifts as students study. Specifically, assuming study tactics are proximal causes of achievement and that students are self-regulating, they change tactics in response to changing goals. Questionnaire items rarely
reflect temporal qualities of SRL (Hadwin, et al., 2001). Conventional methods for assessing strategic processing (e.g., surveys, interviews) are intended to monitor how students conduct their normal academic learning, and can be adapted to refer to individual courses/tasks (Winne & Perry, 2000). Responses to survey instruments don’t capture this variation in goals and, thus, correlations between goal orientation and achievement will be attenuated. Thus, it would be more correct to say that the instruments have measured strategic processing as an aptitude or a trait (Winne & Perry, 2000), or assess students’ predispositions to conduct learning in particular ways (Biggs, 1993; Kember & Gow, 1989).

Researchers must be careful when interpreting self-report data, taking care not to generalize invalidly about how students feel or what they remember about learning as it happens “on the fly” (Winne, 2004, p. 261).

Summary

While self-reports about goal orientation unequivocally represent students’ interpretations about some type(s) of goal(s) they believe they hold or may adopt in some unspecified near-term “normal” studying session, self-reports may not accurately indicate what goals students orient to as they study and self-regulate studying in response to unfolding circumstances. The content of thoughts about goal orientation describes what individuals perceive about themselves in the context of remembered task conditions. In this situation, variance in responses can reflect differences in goal orientation, in perceptions about the context, and in what is remembered (Winne, 2004). The “true” origin of variance can’t be identified in a self-report datum.
There has been a dramatic upsurge in the use of some form of process-tracing analysis in order to piece together the evolution of a person's mental activities during complex work situations such as as problem-solving (Salvucci & Anderson, 1998), reading comprehension (Salvucci & Anderson, 2001) or decision making (Payne, Bettman, & Johnson, 1993). Despite Ericsson and Simon's (1993) theoretical account of the conditions in which verbal reports are valid and recommendations concerning the use of practice at making such reports together with the careful phrasing of instructions, there always will and should be some doubt associated with inferences about cognition based on verbal report alone. This doubt can be reduced where data obtained from general behavioral records and verbal reports are combined, categorized, structured and represented although how this is done not only varies considerably but also is often not reported fully (Patrick & James, 2004).

All the aforementioned issues highlight needs to seek new technology-based methods that compensate for limitations of traditional methods in capturing motivational variation on the fly and relating these more directly to studying tactics that are the engines of achievement. Building on the concept of trace methodologies (Winne, 1982), a goal-tracing method was invented to minimize conceptual ambiguities and model on-the-fly processes in goal-setting and self-regulated learning. Specifically, I operationalized students' expressions of goal orientation on the fly by (a) use of a tool for tagging content in a way that reflected goal orientations and (b) following hyperlinks that were named to match types of goal orientations. Study tactics were operationalized as students' choice
between these tools. In the next section, I elaborate these methods. Greater prominence would to be given to aspects in terms of how the method is formulated, carried out and the associated rationale.
CHAPTER 3: METHODOLOGY OF OPERATIONALIZING ACHIEVEMENT GOAL ORIENTATIONS

Goal orientation and intrinsic / extrinsic motivation

Intrinsic motivation, identified as an important component in the achievement goal nomological network (Ames, 1992; Dweck, 1986; Nicholls, 1989), is manifest in the enjoyment of and interest in an activity for its own sake (Ryan, 1992). Substantial research has suggested that mastery goals are facilitative of intrinsic motivation, whereas performance goals are said to have negative effects (Deci & Ryan, 1990; Heyman & Dweck, 1992; Nicholls, 1989). Mastery goals are posited to promote intrinsic motivation by fostering perceptions of challenge, encouraging task involvement, generating excitement, and supporting self-determination, whereas performance goals are portrayed as undermining intrinsic motivation by instilling perceptions of threat, disrupting task involvement, and eliciting anxiety and evaluative pressure (Elliot & Harackiewicz, 1996; Nicholls, 1989). Given no operationalized definitions of goal orientation thus far and the theoretically close relationships between goal orientation and intrinsic motivation, it would be good to start by reviewing available behavioural measures of intrinsic / extrinsic motivation as a way to approach operationally defining goal orientation.
Behavioural measures of intrinsic / extrinsic motivation

Multiple attempts have been made to operationalize intrinsic motivation. To date, the only non-self-report operationalizations of goal orientation are (a) the free-choice paradigm, which has been extensively used for over three decades in laboratory research on intrinsic motivation (e.g., Deci, Betley, Kahle, Abrams, & Porac, 1981; Reeve & Nix, 1997; Ryan, Mims, & Koestner, 1983; for review, see Cameron & Pierce, 1994); and, (b) task choice (Butler, 1987). In the free-choice paradigm, after having experienced particular experimental conditions, participants are told that the experiment is over and are provided with opportunity to engage again in the prior activity if they desire. Participants are then left alone in the experimental room with the target task as well as various distractor activities, and observed unobtrusively. The time spent on the target activity represents the measure of participants' intrinsic motivation toward the experimental task when external contingencies (e.g., extrinsic reward, pressure, or contingency to do so) are no longer operative. The underlying rationale is that the more an individual persists at the experimental activity, the more intrinsically motivated he/she is regarding that task. This measure has been the mainstay through which the dynamics of intrinsic motivation have been experimentally studied.

Despite its proven utility and Rawsthorne and Elliot's (1999) meta-analysis that found self-reported performance goals were associated with significantly less behavioural persistence relative to self-reported mastery goals, this behavioral index of intrinsic motivation is particularly useful in laboratory conditions.
Regrettably, it is not as useful in real-life conditions, such as sport, where the free choice measure cannot be readily used for practical reasons (Vallerand, 2004). As well, Bandura (1986) commented on the use of free-time measures stating: “How long one persists in a given activity will vary depending upon the alternatives available in the situation” (p. 243). It is conceivable that more attractive alternatives could have changed the results of studies using free-time measures.

In other instances, researchers used task choice as the measure of intrinsic motivation. It is different from the persistence measure, which is employed on children especially. For example, Butler (1987) asked fifth- and sixth-graders how many extra tasks they would like to receive — children who desired to continue on more tasks were assessed with greater intrinsic interest than other children who did not. But again, this is subject to other contextual factors such as fatigue left from previous tasks.

Both the persistence on task and task choice measures possess the limitation of being a post-performance measure, which can be a problem under some circumstances (Reeve & Nix, 1997). For instance, observers sometimes present a potentially interesting activity, such as a puzzle, to a subject and look for the emergence of intrinsic motivation while doing the task, without the opportunity of a post-performance, free-choice interval. To address this pitfall, Reeve and Nix (1997) adopted acts of exploration and facial displays of interest during puzzle solving as within-performance behavioural expressions of intrinsic motivation. Their data validated these two behavioural indicators. Hand speed,
comprehensiveness of investigation, and richness of investigation emerged as a coherent cluster of exploration behaviours that constituted the essence of intrinsically motivated exploration. Eye contact emerged as the indicator of an intrinsically motivated facial display.

These measures undoubtedly provide observers with nonintrusive behavioural markers to infer involvement as people engage tasks in the absence of external contingencies. Although possible criticisms might be that more mental work is more likely to occur in lieu of covert exploration of challenging tasks, with a longer delay or withholding of their manual exploration, this has been a huge step in seeking alternative measures to motivational constructs.

Goal-tracing methodology in multimedia learning environments

Fortunately, modern technology lends a hand to seeking solutions to behavioural measures of cognitive and motivational variables. Multimedia learning models have been developed to guide researchers to identify variables that matter in multimedia learning. For instance, Astleitner and Wiesner (2004) proposed a model that blends cognitive and motivational aspects of memory use and learning. It recognizes that learners must manage mental resources, such as focusing attention, integrating representations of information and metacognitively monitoring progress made in learning. Resources are managed as a function of motivational parameters whose values are set when learners set goals. When learners re-evaluate and modify goals, outcome expectations and incentives are reframed, and action control must be judiciously exercised to pursue goals in the face of competing demands.
Astleitner and Wiesner present their model as an integrated and comprehensive model of multimedia learning and motivation. They believe it can stimulate multimedia research in a variety of areas, such as the motivational qualities of multimedia environments, personality characteristics linked with the theoretical components, and aptitude-treatment-interaction research. Despite these improvements, a basic question remains: "What do we know about learners' motivation in multimedia learning environments?"

There certainly are several reasons that impede answering this question. For example, which motivational constructs should be examined? How should these variables be operationally defined and measured? How can these data contribute to investigating the dynamic self-regulated learning process? In this study, I wish to track down motivational constructs in multimedia environments by focusing on achievement goal orientation as an instance to demonstrate how tracing methodology can be utilized to fuel research in this field. This basically involves two stages.

**Stage I: Developing tags and traces of goal orientation**

In multimedia learning environments, it is mundane to point out that learning is a partial function of the student's use of cognitive tools provided by the software. Some tools appear to promote deep understanding by helping students actively construct knowledge (Pea, 1985); or reflect on their problem solving processes, such as hypothesis generation (Lajoie, 2005). Other tools seem to promote surface level learning, such as highlighting portions of content for rote memorization or clicking a button to seek correct answers to questions. However,
no absolute standard differentiates surface-level from deep-level cognitive tools. Whether use of a tool leads to surface or deep learning depends on the agent who defines its function (Winne, 1979). Thus, inferring a link between goals and behavior based solely on a researcher's classification of a tool's function cannot offer a complete solution. Learner's perceptions and interpretations matter.

In my research, I used the multimedia environment gStudy (see Figure 1). gStudy is an advanced multimedia learning system that offers nearly 30 tools students can use to operate on structured multimedia content represented in hypertext markup language (HTML) and packaged for study as learning kits. (Winne et al., 2006 and Nesbit & Winne, 2007 provide fuller descriptions.) Because gStudy presents documents through a web browser, learning kits may contain media commonly found on the web such as text, video, diagrams, and video clips. As learners work in a learning kit, they use gStudy tools to create information objects as well as hyperlinks connecting those information objects. gStudy's tools include: making notes based on a choice of schemas (e.g., question and answer, summary, etc.), tagging selected content to classify content by properties (e.g., important, review this, don't understand, etc.), hyperlinks that expose new information according to the content developer's model of the domain, constructing new glossary entries, drawing and manipulating concept maps to assemble information within and across elements of the content (e.g., selections in a text; among notes, glossary items, etc.), a powerful multi-faceted search tool, and a chatting tool, to name a few. In short,
students have access to a wide variety of cognitive tools that afford them options for exercising and expressing agency as they construct knowledge.

Figure 1 A screenshot of gStudy user interface.

In my study, the theoretical account of types of goals was exposed to students in the form of tags they could use to catalogue content. As students choose content and tag their selection, they manifest goals they hold. For example, tagging a selection as “I want to know about this” identifies a mastery goal whereas a tag of “Review this to earn higher marks” corresponds to a performance goal. Two students who select the same content can express different goals by the tags they assign to their selection. As well, a student also can apply multiple tags to the same selection of content they study. If this
happens, traces provide evidence that the student simultaneously held multiple goals regarding that content. The key to this method is to justify the labels for the tags so they both (a) represent researchers' theory of goals as accurately as possible and (b) communicate this message clearly to the student.

The tags offered to students were justified by two means. First, goal theory provides a basis for composing these terms and phrases. I grounded my work within the currently prevalent 2 x 2 goal framework of goal type and approach/avoidance model developed by Elliot and McGregor (2001). According to this model, mastery-approach students tend to focus on learning and command of the content or task. This orientation is theoretically related to a series of adaptive outcomes, such as higher levels of efficacy, interest, persistence, the use of more cognitive and metacognitive strategies, as well as better performance (Pintrich, 2000b). The inherently instrumental nature of a performance-approach goal parallels mastery-approach goals in their common need for achievement but diverges from mastery-approach orientation in emphasizing extrinsic achievement outcomes (Elliot, 1997). Performance-avoidance goals, on the other hand, are posited to link to anxiety and task distraction that produce a helpless pattern of engagement (Elliot & Church, 1997) and evoke a host of negative processes, such as distraction, anxiety, self-protective divestment. These undermine performance in most achievement settings (Elliott, Shell, & Henry, 2005) owing to a focus on avoiding negative or undesirable events (Linnenbrink & Pintrich, 2000). Mastery-avoidance goals entail striving to avoid losing one's skills and abilities (or having their
development stagnate), forgetting what one has learned, misunderstanding material, or leaving a task incomplete or unmastered. They are most likely to be pursued when individuals discover, or become concerned, that their skills or abilities are in a state of deterioration (Elliot, 1999). Therefore, these indifferent individuals may experience neither the benefits nor the costs associated with the other achievement goals (Elliot & McGregor, 2001).

Second, to validate that my interpretation of tags was shared by students like those participating in my study, I conducted a pilot study. This study is described in Chapter 4.

In the gStudy learning environment, a learning strategy is operationalized by the cognitive tool use. In addition, I hypothesize that choices between cognitive tools in gStudy, aside from meanings their names convey, may reflect goals. For example, compared to tagging, hyperlink clicking is an effort-minimizing behavior. A student need do nothing more than click to express goal orientation versus the 3-step tagging procedure (select content, mouse-click the selection, choose a tag from a contextual popup menu). While this difference in effort required to use a tool may appear small, it nonetheless may further distinguish a mastery goal student from a performance goal student. Hence, two sets of behavioural measures can be combined to define goal setting operationally: choices of tags and choices between tools.
Stage II: Analyzing trace data to link motivated actions to goals orientations

The use of a computer-tracking system provides a number of unique data-collection possibilities that are not available through other collection techniques. In contrast to paper-and-pencil–based studies, these data are already digitalized, replete with valuable information such as time, key presses, mouse clicks, and a summary of the usage (Harvey & Nelson, 1995). With this approach, behavioural data are recorded automatically and are, therefore, much less expensive but possibly more informative than data collected by traditional methods. Although the data collected with such a system can be overwhelming in amount and difficult to analyze (Schwier & Misanchuk, 1990), the unobtrusive nature of this method enables researchers to track the experiences of a learner in a non-linear environment without disrupting the learner's navigation through the program, and more importantly, to obtain data in real-time so that researchers have the facility to replay them together, thus offering a “virtual” re-creation of learners’ actions.

As students select and use tools in gStudy, the system collects information on the fly about their choices. These are logged at the level of a software event and written to an XML file time-stamped to the millisecond. This XML file creates a transcript containing the events during students’ interaction with the software and the time when that event occurred (see Figure 2). These events represent individual transcript elements such as downloading a kit, moving from one page to another, clicking a button, or creating a new window. As a learner uses each tool, gStudy records in detail all the events involved that
make up the composite a studying action. The intent of this log file is to allow researchers to reconstruct precisely what students do as they study.

In Stage II, log analysis is performed with an adapted parser-miner tool, *Log Validator* (Xu, Nesbit, Zhou, & Winne, 2007). This tool serves two main purposes: identifying a time-sequenced list of actions a particular student (or a group of students) performed, and determining learning patterns extracted from multiple sequences of actions.

To prepare for parsing a log file, I create an action library that specifies how each multi-event action is defined in terms of the several or many fine-grained events recorded as trace data in the log. For example, the action of making a note within a concept map in gStudy contains such events included in the action library as: open a concept map window, selecting “make a new note” from the map menu, posting to the display a new note pop-up window, selection
of a particular template (type of note), inputting information into the fields to instantiate the note, and closing the note window (Figure 3). Some actions can be constituted using varying events, e.g., a window can be opened using a menu selection or a keyboard shortcut in gStudy's interface. Once actions are listed in an action library, I use log validator to parse (identify) actions in the stream of data in each student's log file (or files, if the student studied over multiple sessions). The output of this parsing analysis is a time-sequenced list of actions that represent the students' studying (Figure 4). Preliminary statistics describing the actions are available in this step, such as the type of actions, frequency counts of the times of occurrence of an action, and the time spent on completing an action (Figure 5).

**Figure 3**  A screenshot of Action Library user interface.

<table>
<thead>
<tr>
<th>Action Library</th>
<th>Action Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>Make_New_CMAP</td>
<td>&lt;ConceptMapView.NoteSelect,ButtonAction&gt;</td>
</tr>
<tr>
<td>Make_Note_in_CMAP</td>
<td>&lt;note,created&gt;</td>
</tr>
<tr>
<td>Drag_Note_into_CMAP</td>
<td>&lt;MainWindow&gt;NoteView.NoteList,ListViewSelection&gt;</td>
</tr>
<tr>
<td>Drag_Note_into_CMAP</td>
<td>&lt;MainWindow&gt;NoteView.DetailPanel,DataPanelModelChange&gt;</td>
</tr>
<tr>
<td>Delete_Object_in_CMAP</td>
<td>&lt;conceptMap,created&gt;</td>
</tr>
<tr>
<td>Make_Glossary_in_CMAP</td>
<td>&lt;MainWindow,Opened&gt;</td>
</tr>
<tr>
<td>Make_Glossary_in_CMAP</td>
<td>&lt;MainWindow,FocusObtained&gt;</td>
</tr>
<tr>
<td>Make_Link_in_CMAP</td>
<td>&lt;note,updated&gt;</td>
</tr>
<tr>
<td>Delete_CMAP</td>
<td></td>
</tr>
<tr>
<td>Hyperlink_Clicking</td>
<td></td>
</tr>
<tr>
<td>Apply_Label_To_Text</td>
<td></td>
</tr>
<tr>
<td>Apply_Label_To_Text</td>
<td></td>
</tr>
<tr>
<td>Kit_Selection</td>
<td></td>
</tr>
<tr>
<td>TOC_Selection</td>
<td></td>
</tr>
<tr>
<td>Apply_Label_To_Text</td>
<td></td>
</tr>
</tbody>
</table>
Figure 4  A snapshot of the parsing output — action list.

<table>
<thead>
<tr>
<th>Action Name</th>
<th>Template</th>
<th>Start Time</th>
<th>Duration(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Log_Start</td>
<td>Doc_Panel.Important to know for test</td>
<td>2007.01.17T12.31.50.773</td>
<td>0.0</td>
</tr>
<tr>
<td>AL_pap</td>
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<td>0.587</td>
</tr>
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<td>2007.01.17T12.35.04.916</td>
<td>0.688</td>
</tr>
<tr>
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<td>Doc_Panel.Important to know for test</td>
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<td>0.753</td>
</tr>
<tr>
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<td>2007.01.17T12.36.29.429</td>
<td>0.937</td>
</tr>
<tr>
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<td>2007.01.17T12.36.57.259</td>
<td>1.123</td>
</tr>
<tr>
<td>AL_pap</td>
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</tr>
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<td><a href="http://www.sfu.ca/%7Emzhou2/Link8-map.html">http://www.sfu.ca/%7Emzhou2/Link8-map.html</a></td>
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<td>22.288</td>
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<tr>
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</tr>
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</tr>
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<td>HC</td>
<td><a href="http://www.sfu.ca/%7Emzhou2/Link10-pav.html">http://www.sfu.ca/%7Emzhou2/Link10-pav.html</a></td>
<td>2007.01.17T12.47.23.083</td>
<td>12.062</td>
</tr>
<tr>
<td>HC</td>
<td><a href="http://www.sfu.ca/%7Emzhou2/Link10-pap-ans.html">http://www.sfu.ca/%7Emzhou2/Link10-pap-ans.html</a></td>
<td>2007.01.17T12.47.57.681</td>
<td>6.01</td>
</tr>
<tr>
<td>HC</td>
<td><a href="http://www.sfu.ca/%7Emzhou2/Link10-map.html">http://www.sfu.ca/%7Emzhou2/Link10-map.html</a></td>
<td>2007.01.17T12.48.15.319</td>
<td>34.668</td>
</tr>
<tr>
<td>Log_End</td>
<td></td>
<td>2007.01.17T12.50.01.688</td>
<td>0.0</td>
</tr>
</tbody>
</table>

Figure 5  A snapshot of the parsing output — action statistics.

LogValidator

Source folder...  Action library  Parameter  Parse  Mine  Save

Parameters
- Maximal Timeout(s) 60

General Statistics
- Number of Logs 1
- Number of Events 1134
- Number of Actions 148
- Number of Action Types 12
- Number of Noisy Events 856
- Duration of Session 1852.185

Action Statistics
- Drag_Note_into_CMAP 7 9.002143
- Make_Note_in_CMAP 7 23.797573
- Delete_Object_in_CMAP 3 0.0
- Delete_CMAP 1 0.09
- Apply_Label_To_Text 11 1.2081891
- TOC_Selection 71 0.0
- Kit_Selection 26 0.0
- Log_Start 10.0
- Make_Glossary_in_CMAP 1 0.09
- Hyperlink_Clicking 12 0.0
- Log_End 1 0.0
- Make_Link_in_CMAP 7 0.01299998
An important feature of the action library is flexible granularity control. Granularity or grain size refers to the "level of detail" at which researchers decide *a priori* to address research questions in learning science. The issue of granularity arises not because of the operational definitions of the examined constructs but because researchers intend to model how an individual learns in different levels (Winne, 2006b). A student could be labeled either as an "active learner" at a general level or a "note-reviewing" learner specifically. In the action library, researchers can aggregate lower-level learning events into bigger chunks by decreasing the granularity level. They can also divide coarser-grained events into smaller units to increase granularity. I can also modulate this analysis by specifying several parameters, such as the time boundary (span) for a set of actions that make up a learning strategy, the content selected and so on. I believe this flexibility to explore grain size is critical to new investigations of learning in multimedia environments.

The methods for quantitatively analyzing trace data primarily inform about frequency counts of actions that learners perform (e.g., Lawless & Kulikowich, 1996; Barab, Bowdish, Young, & Owen, 1996; Nesbit, et al, 2007), rather than transitions between actions. These analyses fail to capture the patterns and dynamic processes that characterize an individual's navigation within hypermedia environments (Barab, Fajen, Kulikowich, & Young, 1996). To interpret which goals students establish and how they pursue goals as reflected by choices among cognitive tools during their engagement in goal-directed activities, it is necessary to go beyond simple frequency counts of actions and correlations of
those counts with other variables. With log validator, I can investigate individual
differences in patterns of learners' action sequences or treatment-induced group
differences among those patterns. One approach to this problem is a matter of
discovering sequences of actions that are common to a group of learners. (See
Winne, Gupta, & Nesbit, 1994, for a sequential analysis method based on graph
theory.) Each pattern represents some common action sequences that are
observed among students in a group (e.g., an experimental group or a
classroom). The patterns can then be aggregated while preserving their
sequence to infer higher-order structures from them. This allows building up even
larger "learning strategies" of how students' behavior expresses their goals.
Detailed description concerning pattern location, together with its application in
the field of educational psychology can be found in Chapter 6.

Given reasons outlined in Chapter 1 regarding the use of alternative ways
to operationalize motivational constructs beyond conventional surveys or
interviews, this state-of-the-art goal-tracing methodology provides me with
opportunities to address the concerns by testing (a) whether learners'
behavioural choices accord with theoretical accounts of how goal orientation
affects studying which determines achievement, (b) whether and how goal
orientation develops across contexts and individuals and impacts studying tactic
use, and (c) whether different types of goal orientations are adopted within a
studying session. In the next sections, a series of hypotheses are tested,
following the pilot study to validate the tags representing goal orientations.
CHAPTER 4: PILOT STUDY

In multimedia learning environments, it is not satisfactory to infer a link between goals and behavior solely based on a researcher's classification of a tool's function. Any cognitive tool can be used in a way that leads to surface or deep learning, for instance, depending on the student-as-agent who defines its function. No absolute standard differentiates surface-level from deep-level cognitive tools. Rather than dictate tools' affordances or effects, theoretical accounts of a goal orientation can be exposed to students as a description that tags a tool. Students then use the tool according to its tag to represent goals they hold when they choose that tagged tool.

As no previous study corroborates behavioural expressions of achievement goals, I performed a pilot study first to ensure the validity and reliability of behavioural indicators I have defined for achievement goal orientation. Thus, the pilot study's purpose was to justify the semantic content of tags that would be used in the tracing methodology by coupling learners' selections of tags with their self-reports on goal orientation. The purpose of subsequent main studies was to employ the validated behavioural goal expressions to investigate my main research questions.
Participants

21 undergraduate and graduate students (9 females, 12 males) who are now studying in North America participated with consent obtained first in September to October, 2006.

Procedure

1. Participants were informed they would study a passage about hypnosis and take a posttest. They were told explicitly their test scores would be entered into a database for researchers to compare their scores to other participants' (In fact, the posttest was not administered because the test performance was not a variable of the researcher’s interest). The purpose of this was to remove concern that the induction of goal orientation often minimizes the contrast between mastery and performance goals (Brophy, 2005).

2. The 12-item Achievement Goal Questionnaire (AGQ; Elliot & McGregor, 2001), which reflects all four types of goal orientations was administered with minor revisions to accommodate our context by replacing “this class” in the original version with “this experiment”, and replacing “other students” with “other participants”. This questionnaire is one of the most popular self-report instruments of achievement goals. Participants indicated their perceived appropriateness of each item using a scale from 1 (not at all true of me) to 7 (very true of me). Previous analyses of this instrument have reported a clear four-factor structure, with each of the achievement goal factors represented by three items showing high internal consistency (e.g., Elliot & McGregor, 2001). A complete list of the items is in Appendix B.
3. At their own pace, participants read a 300-word article presenting a definition of hypnosis, basic information about this phenomenon, and two debates about hypnosis. It was excerpted from a chapter about hypnosis in *Psychology: The adaptive mind* (Nairne, 2000), a college textbook not likely to have been encountered by the subjects. The topic was chosen to be nontechnical but expected to arouse a certain level of interest, with a plausible likelihood that students' background knowledge, differing coursework and experiences would not introduce too much variance in their comprehension.

4. As participants read the text, they received the instructions as below:

Suppose you have the following 16 labels (tags) to annotate the above article while you are reading to help with your understanding and reviewing (Note: the labels are not for the article as a whole, but means while you are reading this article, you will stop and select some words/sentences, and give it a label). Please choose five of them you feel you would most likely use.

Table 1 shows the four types of labels, corresponding to factors of goal orientation, with four labels for each). The content was designed by paraphrasing the theoretical accounts of the 2 x 2 achievement goal framework described by Elliot and McGregor (2001). Labels were provided in a random order. The task was for the participants to choose five labels that would most likely be used (not in a particular order) during their studying.
Table 1  Labels Representing Four Types of Goal Orientations

<table>
<thead>
<tr>
<th>Goal Orientation</th>
<th>Labels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mastery-approach</td>
<td>Interesting</td>
</tr>
<tr>
<td></td>
<td>Good evidence</td>
</tr>
<tr>
<td></td>
<td>I want to learn more about this</td>
</tr>
<tr>
<td></td>
<td>Extra info is needed</td>
</tr>
<tr>
<td>Performance-approach</td>
<td>Know this for test</td>
</tr>
<tr>
<td></td>
<td>Could be in test</td>
</tr>
<tr>
<td></td>
<td>Review for test</td>
</tr>
<tr>
<td></td>
<td>Remember this for test</td>
</tr>
<tr>
<td>Performance-avoidance</td>
<td>Too complicated</td>
</tr>
<tr>
<td></td>
<td>I'd better know this</td>
</tr>
<tr>
<td></td>
<td>Too hard to understand</td>
</tr>
<tr>
<td></td>
<td>Might not be tested</td>
</tr>
<tr>
<td>Mastery-avoidance</td>
<td>Worried I might forget</td>
</tr>
<tr>
<td></td>
<td>Reread to avoid confusion</td>
</tr>
<tr>
<td></td>
<td>I don't want to miss this info</td>
</tr>
<tr>
<td></td>
<td>Worried I am confused</td>
</tr>
</tbody>
</table>

Results

The data screening on the label choices satisfied normality and linearity, and no outliers were detected. As displayed in Table 2, no statistically detectable relationships were detected. Exploratory factor analyses using principal components extraction and oblique (promax) rotation produced 7 factors, accounting for 81.01% of the total variance. While prior factor analyses confirm Elliot's 2 x 2 model (e.g., Elliot & McGregor, 2001), actual choices of labels with our sample do not.

Hierarchical cluster analysis was used to group participants as a function of items in the self-report measure of goal orientation. A 4-cluster solution was finalized based on discriminant function analyses which correctly classified 100% of original grouped cases. Students we labelled Mastery-Dominant (group 1, N = 7) reported high mastery goals and relatively low performance goals. Group 4
was labelled *Performance-Dominant* (N = 4). Group 2 was labelled *Inactive* (N = 5) because members did not score high on any goal orientation. Group 3 (*Highly-Motivated*, N = 5) exhibited high levels of all four achievement goals (see Figure 6).

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Correlation Coefficients of Goal Orientations with Label Choices (N = 21)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labels</td>
<td>Goals</td>
</tr>
<tr>
<td>Mastery-approach</td>
<td>.13</td>
</tr>
<tr>
<td>Performance-approach</td>
<td>.18</td>
</tr>
<tr>
<td>Mastery-avoidance</td>
<td>.17</td>
</tr>
<tr>
<td>Performance-avoidance</td>
<td>-.21</td>
</tr>
</tbody>
</table>

** ** p < .01

**Figure 6**  Graphic representation of four groups by self-reported goal orientations
To examine differences in labelling among these groups, a univariate analysis of variance (ANOVA) was used to compare label choices grouped by goal orientations (see Table 3). No statistically detectable difference ($p < .05$) was observed, although the Inactive group tended to apply more mastery-approach labels than the other three groups.

<table>
<thead>
<tr>
<th>Label Choices</th>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
<th>Group 4</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mastery-approach</td>
<td>2.00</td>
<td>2.80</td>
<td>2.40</td>
<td>1.25</td>
<td>0.50</td>
<td>1.97</td>
</tr>
<tr>
<td>Performance-approach</td>
<td>1.00</td>
<td>0.20</td>
<td>1.00</td>
<td>0.71</td>
<td>1.41</td>
<td>1.23</td>
</tr>
<tr>
<td>Mastery-avoidance</td>
<td>1.14</td>
<td>0.71</td>
<td>1.20</td>
<td>0.84</td>
<td>0.82</td>
<td>.07</td>
</tr>
<tr>
<td>Performance-avoidance</td>
<td>0.86</td>
<td>1.30</td>
<td>0.40</td>
<td>0.55</td>
<td>1.12</td>
<td>.42</td>
</tr>
</tbody>
</table>

A closer scrutiny of specific labels selected in these two groups found that, of their 35 label choices, Mastery-Dominant learners chose 14 mastery-approach-oriented labels and 8 mastery-avoidance labels. In comparison, among Performance Dominant learners’ 17 different choices, 8 were performance-oriented labels (including 4 approach and 4 avoidance labels). This accords somewhat with findings where mastery goal orientation positively predicts deep processing whereas performance goals predict surface processing (e.g., Anderman, Griesinger, & Westerfield, 1998; Elliot, McGregor, & Gable, 1999).
However, the Inactive and Highly-Motivated groups also chose a large number of mastery-approach-oriented labels.

Profile analysis was then performed to investigate different patterns of label choice. The grouping variable was the four clusters; within-group factors were the four categories of label choice. Figure 7 shows profiles of label choices. The levels test, which assessed whether one group on average selected more or fewer labels than another (regardless of category of labels), indicated there were no statistically detectable differences among the four groups: F (1,3) = 2.70, \( p = .08 \). The flatness test, which assessed whether all labels were selected similarly when collapsed across groups, demonstrated there were significant differences among choices of goal-oriented labels: F (1,3) = 5.43, \( p = .01 \). The parallelism test, which assessed the interaction of groups and label choice, indicated no statistically detectable differences among the shapes of the profiles: F (1,3) = 0.75, \( p = .67 \).
Discussion

Results of the pilot study offered extremely limited support for the position that self-reported goals were consistent with actual behavioral expressions of goal orientations. These results do not support grounded speculations about poor calibration between self-reported goal orientation and traces of goal orientation operationalized as tags chosen to describe studying. However, students' choices to apply tags does indicate they held goal orientations. Following the criteria that a label name has been selected with a frequency above 50% on one type of orientation yet below 50% on the other three, and after consulting colleagues with extensive knowledge of goal orientations, I reconstructed the names of labels and finalized the hyperlink names to be presented to participants in the main studies. The final tags can be found in Table 4.
Table 4  Tags for Labels and Hyperlinks Representing Four Goal Orientations

<table>
<thead>
<tr>
<th>Goals Tools</th>
<th>Mastery-approach</th>
<th>Mastery-avoidance</th>
<th>Performance-approach</th>
<th>Performance-avoidance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Label</td>
<td>I want to learn</td>
<td>Reread to avoid</td>
<td>Important to</td>
<td>Not critical but</td>
</tr>
<tr>
<td></td>
<td>more about this</td>
<td>misinterpretation</td>
<td>know for test</td>
<td>study for test</td>
</tr>
<tr>
<td>Interesting</td>
<td>Worried—I might</td>
<td>Restudy to get</td>
<td>Remember this—</td>
<td></td>
</tr>
<tr>
<td></td>
<td>get this wrong</td>
<td>highest marks</td>
<td>others will know it</td>
<td></td>
</tr>
<tr>
<td>Hyperlink</td>
<td>Find more</td>
<td>Avoid</td>
<td>Take a</td>
<td>Avoid forgetting</td>
</tr>
<tr>
<td></td>
<td>information about misleading</td>
<td>practice test</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>this / See an</td>
<td>about this</td>
<td>on this</td>
<td></td>
</tr>
<tr>
<td></td>
<td>example of this</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

I submit this constitutes a more reliable behavioural measure of goal orientation that describes students' goals while they study than does reflecting on a general disposition expressed as responses to a self-report instrument administered prior to (or after) studying. In part, this is because goals may vary over the course of a single studying session as the learner's grasp of content evolves (or is stymied). Current goal theory may thus not be trusted to describe from point to point learning processes, and it is hard to capture accurately such changing goal adoption via reports.

I configured gStudy in the main study (presented in Chapter 6) wherein hyperlinks and labels were available for students to use as a way to trace their goal orientations when they studied. For example, using an "Important to know
for test" label traces a performance-approach goal. The hyperlink “See an example of this” or “Find out more information about this” directed students to a new webpage that extended information on the topic. A hyperlink of “Take a practice test” was linked to a webpage where students can take a self-test. The hyperlink named “Avoid misunderstanding about this” connected to a webpage which contained further explanation of the term without adding any new information. And the hyperlink “Avoiding forgetting this in test” directed students to a webpage which repeated the same information in a somewhat different way. Applying one or more labels and clicking one or all of these hyperlinks trace a student’s on-the-fly expression of a particular type of goal.

On the basis of the pilot study, several research questions are of my interest to seek answers in the following main study: (a) whether students’ self-reported goal orientations correspond with their behavioral expressions of goal orientations; (b) what is the relationship between achievement goal orientations and achievement (posttest performance); (c) what type of pattern could be identified among all the participants, and (d) how different would the high-achievers be from the low-achievers in terms of their motivation? The review of relevant literature on each research question is included prior to the result presentation.
CHAPTER 5: METHOD

Participants

Volunteer students were recruited from a variety of faculties and departments at a western Canadian university to participate. Students were first handed a consent form to sign and a demographic form to fill out background information (name, sex, year of birth, first language, major, etc.; see Appendix A).

A total of 103 students volunteered to participate. Seventy-six of the participants were female (73.8%) and 27 were male. Ages ranged from 19 to 35 years (M = 23.14, SD = 3.21). 49 were native English speakers (47.6%), and 44 students’ first language was Chinese (42.7%). 88.3% were pursuing bachelor degrees, the rest were pursuing master degrees.

Measures

Achievement goal orientation

The same AGQ as the one in the pilot study was administered. The internal reliability coefficient was .75 for performance-approach goals, .78 for mastery-approach goals, .86 for mastery-avoidance goals and .71 for performance-avoidance goals.

Need for cognition

The scale consisted of 18 items and measured an individual’s tendency to seek, engage in and enjoy effortful cognitive activities (Cacioppo, Petty, & Kao,
1984). Items were answered on a 7-point scale ranging from 1 (not at all true of me) to 7 (very true of me). Due to the conceptualization of need for cognition (NFC) as a one-dimensional construct (Cacioppo et al., 1996), students’ responses for need for cognition were aggregated over all items. High NFC individuals are theoretically more likely to engage in and enjoy thinking than their low NFC counterparts. The scale showed a high internal consistency (Cronbach's alpha = .89). The scale is in Appendix C.

**Achievement test**

The posttest was comprised of five multiple questions and five short answer questions presented on paper. All items were relevant to the material participants were assigned. Some items required rote memorization of facts whereas some required deep understanding of the content. The test was presented in Appendix D. The internal consistency was quite acceptable (Cronbach's alpha = .69).

**Chapter**

The passage was excerpted from the same chapter consulted in the first study by reducing portions of the chapter to approximately 1500 words in length. It consisted of five sections, each introduced with a title or subtitle; all original subheadings were kept intact. The text was specifically revised so that the content of each paragraph primarily addressed one particular issue about hypnosis with a main idea; an important detail, which was more specific information that further expanded or supported a main idea; and an unimportant
detail, which was specific information that was not relevant to understanding the main ideas. The text was presented in Appendix E.

**Software**

The material was presented with the software called gStudy (see Chapter 3 for full descriptions) after the studying material was transformed into a learning kit displayed in the web browser (see Figure 1). As students studied the kit, they could use the label tool in gStudy to mark content which they perceived to be important. The list of labels contained in a random order 8 different label names as suggested by the pilot study. Students could apply one or more labels to the same selected text. In addition, there were 10 groups of hyperlinks, four in each group mixed in a random order, in the column next to the body text. Based on the result of the pilot study, the titles of the hyperlinks represented different types of goal orientation. As the students applied labels or clicked the hyperlinks, gStudy time-stamped all the events involved in these actions performed, such as: which content was selected, when the selection was made, which label name was chosen, which hyperlink was clicked, and how long it took to apply a label or read the content in the hyperlink. These data constituted traces of learning activities as students engaged with the reading.

**Procedure**

1. All participants were asked to make appointments for a one-hour experimental session. Students who completed the session were paid $15. No one withdrew during a session. At the outset of the session, written consent was
requested and obtained by the researcher from each student prior to administering the questionnaires and studying the material. In the consent forms, participants were informed that all the information and data were confidential and would be used only for research purposes.

2. Students were informed that they would be given material to learn and tested with 5 multiple-choice questions as well as 5 short answer items on the material at the end of the session. They were encouraged to work at their usual pace and told that they could stop studying and begin the test whenever they wished. The Achievement Goal Questionnaire (Elliot & McGregor, 2001) and the Need for Cognition inventory (Cacioppo, Petty, & Kao, 1984) were administered in hardcopy after these instructions.

3. Participants were invited to a computer workstation to study the material using gStudy. Before starting, participants were shown how to use gStudy tools (only the label tool and hyperlinks in this study), and provided with a short practice session to gain more familiarity with the tools while reading a small sample paragraph. Once the students informed the researcher that they were ready, they were directed to the experiment reading material and started studying. The only instruction they received was to study the material however they wished.

4. Upon completion of their study, students were presented with a small Latin-square game (see Appendix F) to erase their memory of what they just read. They were asked to do their best to solve the three tasks with varying
difficulty levels within 8 minutes. After this, they were allowed to review the article with their annotations for 5 minutes (only rereading) before taking the test.

5. At the end of restudying the material, they were provided with an experimenter-designed test.
CHAPTER 6: RESULTS AND DISCUSSIONS

Research question 1: Calibration of self-reported and actual goal orientation

Empirical data demonstrate that students are poor calibrators in self-reporting their use of study tactics (e.g., Winne & Jamieson-Noel, 2002), reporting having planned a method for studying on average one third more than traces of actual studying behaviour indicated (Jamieson-Noel & Winne, 2003). Extending this area of research and providing more empirical evidence of the utility of trace data, the purpose here was to determine whether students’ self-report of achievement goal orientations accorded with the goal orientations as reflected by the label/hyperlinks they selected during studying.

Descriptive statistics

Self-report data

Scale scores on the self-reported goal orientations were calculated for each participant based on theoretically predefined types of goals by summing responses across the three items for each scale. Table 5 shows the means, medians, standard deviations, skewness and kurtosis of these variables.
Table 5 Properties of Self-Reported Goal Orientation Variables (N = 103)

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Mdn</th>
<th>SD</th>
<th>Skewness (SE = .24)</th>
<th>Kurtosis (SE = .47)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mastery-approach</td>
<td>4.74</td>
<td>5.00</td>
<td>1.29</td>
<td>-.34</td>
<td>-.71</td>
</tr>
<tr>
<td>Performance-approach</td>
<td>4.16</td>
<td>4.30</td>
<td>1.62</td>
<td>-.45</td>
<td>-.78</td>
</tr>
<tr>
<td>Mastery-avoidance</td>
<td>4.04</td>
<td>4.30</td>
<td>1.49</td>
<td>-.18</td>
<td>-.35</td>
</tr>
<tr>
<td>Performance-avoidance</td>
<td>4.30</td>
<td>4.30</td>
<td>1.35</td>
<td>-.52</td>
<td>.30</td>
</tr>
<tr>
<td>Need for cognition</td>
<td>4.42</td>
<td>4.44</td>
<td>0.96</td>
<td>-.61</td>
<td>.50</td>
</tr>
</tbody>
</table>

Learning activity (Trace data)

The time spent on the first reading of the material created a *duration* variable (Mdn = 16.83 min). Actions performed in gStudy while reading the material were summed to create a *number of actions* variable (Mdn = 22). In a similar fashion, a *number of labels* variable (Mdn = 12) and a *number of hyperlinks* variable (Mdn = 8) were recorded based on the total number of labels students applied and hyperlinks they clicked, respectively. Skewness statistics for these variables were acceptable, varying between .71 and 1.06. The number of actions was divided by the duration to obtain an action rate variable (Mdn = .73 actions per minute). This variable had high positive skew so a logarithmic (base 10) transformation was applied to reduce skewness (Tabachnick & Fidell, 2007). Transformation of skewed variables can be a valuable method for decreasing type I error in inferential tests which assume normal distributions. While maintaining ordinal properties of data in the distribution, it still alters the distance
between measurements (Nesbit et al., 2007). Skewness was reduced from 4.08 to 1.38, and kurtosis was reduced from 18.67 to 3.92.

After the log10 transformation, outliers were identified that could jeopardize the assumption of normality. Over the activity variables, another 3 univariate outliers with z-scores exceeding 3.29 \( (p < .001) \) were removed. With 5 missing values, this led to a final sample size of 95. Table 6 shows the means, medians, standard deviations, skewness and kurtosis of the learning activity variables.

<table>
<thead>
<tr>
<th>Table 6</th>
<th>Properties of Learning Activity Variables (N = 95)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
</tr>
<tr>
<td>Duration (minutes)</td>
<td>17.92</td>
</tr>
<tr>
<td>Total number of action</td>
<td>26.72</td>
</tr>
<tr>
<td>Action rate †</td>
<td>-.10</td>
</tr>
<tr>
<td>Number of labels</td>
<td>13.32</td>
</tr>
<tr>
<td>Number of hyperlinks</td>
<td>13.40</td>
</tr>
</tbody>
</table>

*Note: †Variable was transformed by the log10 function.*

**Calibration between self-report data and trace data**

Correlations among self-report and corresponding trace variables in terms of label use (Table 7) revealed only a rather weak correlation of self-reported performance-avoidance labels \( r = .24, p < .05 \) with performance-avoidance
goals. Meanwhile, students who reported more mastery-approach, performance-approach and performance-avoidance goal orientation tended to apply more performance-avoidance labels as well. With regard to hyperlink clicking, no statistically significant relationships were detected.
Table 7  Correlations among Self-reports and Trace Data of Goal Orientations (N = 95)

<table>
<thead>
<tr>
<th>Label</th>
<th>Mastery-approach</th>
<th>Performance-approach</th>
<th>Mastery-avoidance</th>
<th>Performance-avoidance</th>
</tr>
</thead>
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</table>

Hyperlink

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<th>Mastery-avoidance</th>
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<td>Performance-avoidance</td>
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<td>0.00</td>
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</table>

* p < .05

The near zero correspondence (calibration) between self-report responses about goal orientation and behavioural traces of goal pursuit might seem to undermine the use of self-report inventories. I take this discrepancy as a reflection that students are guided by different perceptions in the different
situations where they generate self-report and trace data. Rogers (1974) used
the term "self-referent decision (SRD)" to describe the relating of the item content
to the self-concept. It is during this stage that the item content interacts with the
memory store. This element could be labeled "self", which may represent an
abstraction of salient self-related experience. The output of the SRD then enters
into the stage of response selection. Hence, individuals' response to
questionnaire, survey, or interview items are not simply in terms of their
momentary reaction to the content of the questions, rather, they respond in ways
that are in line with the self-image and which have a rational basis. In contrast,
the behavior as shown in the trace data is an alternative way to deliver “self”
messages, without involving too much further thinking about establishing a given
type of self-image.

Research question 2: Relationships between achievement goals
and test performance

More recently, theorists have focused on achievement goals,
conceptualized as situationally specific measures of motivational orientation, and
argued that they could be stronger predictors of academic success (Pintrich &
and cognitive elements of learning, showing how achievement goals and learning
expectancies influence students' use of cognitive processes (Covington, 2000;
Nicholls, Patashnick, Cheung, Thorkildsen, & Lauer, 1989; Pintrich, 2003;
Schunk, 2005; Schunk & Zimmerman, 2001). The basic assumption of these
models is that the achievement motives and the intentions that guide students’
academic behavior determine to a great extent the types of cognitive processes they employ in various learning situations. The learning outcome is thus dependent on how students process information (Craik & Lockhart, 1972; Entwistle, 1988).

Recent generations of empirical research have made efforts to investigate learning using computer logs in multimedia learning settings to capture this relationship in a dynamic way. Nesbit et al. (2007) presented a study analyzing the correlation of students' achievement goal orientations and learning tactics as well as learning strategies in multimedia learning. Log-file analyses of learners' study tactics during studying a multimedia document revealed several relationships between reported goal orientation and actual cognitive engagement. For example, mastery goal orientation (approach or avoidance) was negatively related to the amount of highlighting. Furthermore, authors provide a methodological suggestion, claiming that the use of deeper learning tactics could be measured by counting notes or words in notes as traced during their hypermedia learning environment. However, in the subsequent regression analysis, no relationships were statistically detected by regressing seven learning activity variables in multimedia learning settings (e.g., highlights in text, highlight rate, and word productivity in notes) upon the four self-report goal orientations. This failure to reject the null hypothesis could be attributed to (a) the inaccuracy of self-reports, (b) the inability of a one-shot goal statement to reflect adaptive learning tactic use, or (c) participants' perceptions of the ineffectiveness of using tools they were offered.
In a collaborative computer-based modeling task, Sins et al. (2008) tested a conceptual model of relations among achievement goal orientation, self-efficacy, cognitive processing, and achievement. Students' cognitive processing level was assessed by analyzing inter-student online chat logs. As predicted, mastery-approach goal orientation had a significant positive effect on achievement, which was mediated through students' use of deeper processes. But no significant relationship was found between performance-avoidance goal orientation and surface processing, or between surface processing and achievement. Despite the methodological shortcoming of using offline subjective rating-scales to measure achievement goals in these studies of online behavior, the conclusions invite future researchers to investigate further these issues.

**Correlations between learning activity and goal orientation measures**

The correlation matrix relating learning activity measures obtained via gStudy and goal orientations reflected by trace data is presented in Table 8. It is no surprise that duration and number of actions were positively related to label use and hyperlink clicking, regardless of the type of goal orientation they indicate. The four types of goal orientations measured by label use and hyperlink clicking were also correlated in the expected direction.
Table 8  Correlations between Learning Activity Measures and Goal Orientation Trace

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<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
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<tbody>
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</tbody>
</table>

Note: Variable was transformed by the log10 function. MAP = mastery-approach; PAP = performance-approach; MAV = mastery-avoidance; PAV = performance-avoidance; HLink = hyperlinks

* p < .05, ** p < .01,
<table>
<thead>
<tr>
<th>Variable</th>
<th>Information Exploration</th>
<th>Information Labeling</th>
<th>Mastery-approach Labeling</th>
<th>Mastery-avoidance Labeling</th>
<th>Primary Performance</th>
<th>Secondary Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>PAP Hyperlink</td>
<td>.64</td>
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<td>.08</td>
<td>-.06</td>
<td>.06</td>
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<td>PAV Hyperlink</td>
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<td>-.01</td>
<td>.04</td>
<td>.10</td>
<td></td>
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<td>MAV Hyperlink</td>
<td>.85</td>
<td>-.08</td>
<td>-.01</td>
<td>-.24</td>
<td>-.06</td>
<td></td>
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<tr>
<td>MAP Label: I want to learn more about this</td>
<td>-.11</td>
<td>.80</td>
<td>.11</td>
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<td>-.04</td>
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<td>.74</td>
<td>-.06</td>
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<td>-.02</td>
<td></td>
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<td>MAV Label: Worried-I might get this wrong</td>
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<td>.05</td>
<td>.93</td>
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<td>-.16</td>
<td></td>
</tr>
<tr>
<td>MAV Label: Reread to avoid misinterpretation</td>
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<td>-.01</td>
<td>.53</td>
<td>-.15</td>
<td>.50</td>
<td></td>
</tr>
<tr>
<td>PAP Label: Important to know for test</td>
<td>-.07</td>
<td>.15</td>
<td>-.13</td>
<td>.77</td>
<td>.10</td>
<td></td>
</tr>
<tr>
<td>PAV Label: Remember this – others</td>
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<td>-.14</td>
<td>.30</td>
<td>.70</td>
<td>.01</td>
<td></td>
</tr>
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<td>will know it</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PAP Label: Restudy to get highest</td>
<td>-.12</td>
<td>-.06</td>
<td>-.04</td>
<td>-.01</td>
<td>.82</td>
<td></td>
</tr>
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<td>marks</td>
<td></td>
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</tr>
<tr>
<td>PAV Label: Not critical but study for</td>
<td>.17</td>
<td>.03</td>
<td>-.11</td>
<td>.21</td>
<td>.75</td>
<td></td>
</tr>
<tr>
<td>test</td>
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</tbody>
</table>

| Eigenvalues | 2.72 | 1.27 | 1.01 | 1.12 | 1.81 |
| Percentage of variance explained | 22.69% | 10.60% | 8.43% | 9.36% | 15.09% |

Note: Target loadings are in boldface; cross-loadings are underlined. MAP = mastery-approach; PAP = performance-approach; MAV = mastery-avoidance; PAV = performance-avoidance.
Dimensionality of goal orientation reflected in trace data

To investigate the structure of the achievement goal orientation construct based on trace data, I performed exploratory factor analyses using principal components extraction and oblique (promax) rotation. Results are displayed in Table 9. Factors with eigenvalues in excess of 1.0 were retained. Factor loadings greater than or equal to .45 were used to guide interpretation of the factor structure (Tabachnick & Fidell, 2007). Five factors were identified accounting for 66.17% of the total variance. The magnitude of factor loadings was satisfactory ranging from .53 to .93.

A clear split between hyperlink clicking and label use was apparent in the factor structure. All four types of hyperlink clicking actions loaded highly on "information exploration" where the action was performed without differentiating the intention or purpose. Factor loadings displayed a clean factor structure among goal-oriented label use. Both mastery-approach and mastery-avoidance labels loaded, respectively, on the factor as their goal orientation implied, while "Important to know for test" (performance-approach label) and "Remember this – others will know it" (performance-avoidance label) loaded on the "primary performance" factor. Factor loadings for the "secondary performance" factor were high for both "Restudy to get highest marks" (performance-approach label) and "Not critical but study for test" (performance-avoidance label).
Self-reports versus traces of goal orientation as predictors of learning strategy and achievement

Additional correlation analysis was conducted focusing on relationships among goal measures and test performance. In this study, statistically detectable correlations with test performance were only found in goal-orientated hyperlink clicking (as shown in Table 10). Both types of approach goals were positively moderately associated with achievement, yet performance-avoidance goals were surprisingly positively related to test score as well. Trace data of learning activity were overall moderately positively associated with test performance.

Brief discussion

The correlations between traces of different types of goal orientations showed patterns as predicted by the goal theory but the subsequent exploratory factor analysis did not fully replicate the four-dimensional conceptualization of achievement goal orientation outlined previously. In retrospect, the wording of the primary performance labels suggested greater urgency than those of the secondary performance labels and may have involved social comparison. It appears that participants did not differentiate between hyperlinks, perhaps because the decision to click or not to click did not require them to do so or did not “cost” much in terms of effort or thought. The availability of information at the end of the link, regardless of its type, seemed to “invite” clicks. Yet, in the context of applying a label, a decision was required (a) to select particular content to be labelled and (b) to choose a label to apply. This relatively complex process affords greater opportunity to distinguish choices that reflect goal orientation.
Table 10  Correlations between Self-Reports, Goal Orientation Trace, Learning Activities and Test Performance (N = 95)

<table>
<thead>
<tr>
<th></th>
<th>Mastery-approach</th>
<th>Performance-approach</th>
<th>Mastery-avoidance</th>
<th>Performance-avoidance</th>
<th>Test Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-Reported Goal Orientation</td>
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<td></td>
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</tr>
<tr>
<td>Test Score</td>
<td>.06</td>
<td>-.04</td>
<td>-.09</td>
<td>.03</td>
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</tr>
<tr>
<td>Label Choice</td>
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</tr>
<tr>
<td>Test Score</td>
<td>.14</td>
<td>.20</td>
<td>.02</td>
<td>.19</td>
<td></td>
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<tr>
<td>Hyperlink Choice</td>
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</tr>
<tr>
<td>Test Score</td>
<td>.35**</td>
<td>.33**</td>
<td>.15</td>
<td>.35**</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Duration (minutes)</th>
<th>Number of actions of labels</th>
<th>Action rate†</th>
<th>Number of hyperlinks</th>
</tr>
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<tbody>
<tr>
<td>Test Score</td>
<td>.40**</td>
<td>.41**</td>
<td>-.30**</td>
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</tbody>
</table>

*p < .05, **p < .01, †Variable was transformed by the log10 function.
My findings also appear to contradict previous studies wherein traces of students’ actual study tactics were not as robust as self reports in modelling achievement (Jamieson-Noel & Winne, 2003). Jamieson-Noel and Winne interpreted their finding using a forest-tree analogy: Students may have a reasonable view of metacognitive monitoring of the overall use and effects of study tactics (forest) but an inaccurate view of the particular study tactics they use (trees). In the current study, however, trace data were distinguished from self-reports by their moderate associations with test performance.

The present study was also different in that the variable examined here was goal adoption rather than study tactic use. If study tactic use is a proximal cause of achievement, and if self-reported goal orientations cannot reflect systematic changes in study tactics use, then the correlation between goal orientation and achievement will be attenuated. Previous findings indicate incongruence between general level goal orientations and contextual goal interpretations and, thus, underline the importance of subjective interpretations of achievement goals (e.g., Salovaara, 2005). My data also evidence this in the near-zero correlations between self-reported goals and study activities. This contextual characteristic illustrates the need to understand the interplay of motivational and cognitive processes.

On the other hand, the lack of correlation between performance and goal orientation reflected via label use was unexpected. Yet there is a plausible rival interpretation. As expressions of achievement goals, labels are distinguished from hyperlinks in several ways. On one hand, applying labels is a one-time
action, with no further information processing needed. In contrast, hyperlinks
direct students to a linked page, which was either explanatory (presenting
students with opportunities to re-process the same information more clearly),
extending (allowing students to get a deeper understanding) or simple repetition,
as informed by different types of goal orientations. Further processing of the
linked information might have played an important role in affecting later test
performance.

Interestingly, students who clicked more performance-avoidance-oriented
hyperlinks performed better. This counts against the contemporary achievement
goal model according to which performance-avoidance learners are not engaged
in the main aspects of the task owing to their focus on avoiding negative or
undesirable “losses” of achievement (Linnenbrink & Pintrich, 2000). Nonetheless,
the information delivered at the destination of this hyperlink might have actually
helped such students achieve their goal, in part. It restricted students’ knowledge
to the surface meaning of the concept yet contributed to recall items in the
posttest. In no way did this suggest that performance-avoidance hyperlinks
helped students more in this context as compared to other types of goal
orientations, yet individuals who had more access to the repeated information
had a stronger chance to recall what they just read. This might be instrumental
for exams that require recall but still detrimental for the sake of sophisticated
learning.
Research question 3: Does Need for Cognition Interact with Goal Orientation in Predicting Achievement?

Another characteristic that may bear on the ways learners approach a given task is variations in students’ cognitive processing of information and how these variations affect achievement. A theoretically essential property of deep information processing during learning is the students’ willingness to engage in the effortful cognitive activities that constitute deep information processing (Evans, Kirby, & Fabrigar, 2003). The concept of need for cognition (NFC) captures this property because it describes people’s tendency to seek, engage in, and enjoy effortful cognitive activity (Cacioppo & Petty, 1982). Theoretically, students high in NFC are more likely to acquire, organize, elaborate and synthesize information as they study than peers low in NFC. In contrast, students low in NFC theoretically are likely to rely on others, use less resource-demanding cognitive heuristics, and focus on social comparisons to develop and monitor their understanding (Cacioppo, Petty, Feinstein, & Jarvis, 1996).

There is mounting evidence of a positive relation between NFC and performance in a variety of tasks that vary in the intensity or depth of cognitive processing (e.g., Dornic, Ekehammar, & Laaksonen, 1991; Gülgöz, 1996; Petty & Jarvis, 1996; Preckel, Holling, & Vock, 2006, Sadowski & Gülgöz, 1992). Since more effortful information processing may result in more and more retrievable information, need for cognition has an effect on the acquisition of knowledge (Preckel, Holling & Vock, 2006). Differences in information processing as a function of NFC are primarily due to differences in motivation rather than ability, i.e., cognitive processes available during studying (Cacioppo et al., 1996).
various studies have documented positive correlations between NFC and school grades (e.g., Ackerman & Heggestad, 1997; Wilhelm, Schulze, Schmiedek, & Süß, 2003), little or no attention has been devoted to examining how this individual difference variable varies with achievement goals.

From a different motivational perspective, approach-oriented achievement goals – both mastery approach and performance approach – also characterize a motivational tendency to become involved in intense or deep information processing. Elliot, Shell, Henry, and Maier (2005) theorize that mastery-approach goals evoke intense or deep cognitive processing that enhances achievement. Performance-approach goals are posited to evoke many of these same processes but, in contrast to internal standards for understanding that drive monitoring of learning under mastery-approach goals, external standards for achievement drive monitoring under performance-approach goals. Coupled with learners’ choices about how they process information, this focus on external standards that are operationally defined as achievement test items may explain most findings of positive relationships between performance-approach goals and performance measures (Church, Elliot, & Gable, 1999; Lopez, 1999; Wolters, 2004; Urdan, 2004) relative to less consistent relations observed between mastery-approach goal orientation and academic performance (Sideridis, 2004; Lee, Sheldon, & Turban, 2003; Malka & Covington, 2005).

Although it is known that NFC and approach-based goals separately predict positive performance, little is known about their joint relationship to achievement. In the current study, I hope to combine these two constructs that
have been studied separately to date. Only by examining them together can we compare them and estimate their relative efficacy in predicting academic success. Since both constructs theoretically relate to more intense or deeper cognitive processing, I expect they may combine interactively to predict performance. Specifically, I hypothesize that high NFC students with a performance-approach goal orientation will achieve better results than students with mastery-approach goals.

Results and brief discussion

As no statistically detectable correlations were observed between test performance and goal-orientation-attached-labels, relations were examined using Pearson correlations among only goal orientations represented by hyperlink-clicking, need for cognition and achievement (see Table 11). Need for cognition ($M = 4.42$, $Mdn = 4.44$, $SD = 0.96$) was statistically detectably and positively correlated with performance-approach oriented hyperlink clicking ($r = .31$, $p < .01$) but not mastery-approach hyperlink clicking. Students higher in NFC were more likely to probe for more information they perceived as relevant to maximizing achievement. NFC, mastery-approach oriented hyperlink-clicking, and performance-approach oriented hyperlink-clicking were all moderately positively related to test performance.
Table 11  Relationships among Need for Cognition, Goal Orientation Trace and Achievement

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
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</thead>
<tbody>
<tr>
<td>1. Need for cognition</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>2. Mastery-approach hyperlink clicking</td>
<td>.16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Performance-approach hyperlink clicking</td>
<td>.31**</td>
<td>.32**</td>
<td></td>
</tr>
<tr>
<td>4. Achievement</td>
<td>.32**</td>
<td>.35***</td>
<td>.33**</td>
</tr>
</tbody>
</table>

** ** p < .01; *** p < .001

I adopted procedures described by Cohen and Cohen (1988) for testing moderator variables using hierarchical regression models. To test whether NFC moderated mastery-approach goals, as traced by hyperlink clicking, I entered NFC and traces (hyperlink clicking) indicating mastery-approach goals in the first step of a regression model predicting posttest achievement, then the interaction between these variables in the second step. I followed the same procedure in a second regression analysis testing performance-approach goals. Results of each regression analysis are summarized in Table 12 and Table 13.
Table 12  Summary of Hierarchical Regression Predicting Achievement with Need for Cognition (NFC), Mastery-Approach Goals (MAP), and the NFC x MAP Interaction

<table>
<thead>
<tr>
<th>Variable(s)</th>
<th>$R^2$</th>
<th>$\Delta R^2$</th>
<th>Final $\beta$</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Need for cognition</td>
<td>.20</td>
<td>.01</td>
<td>.27</td>
<td>.005</td>
</tr>
<tr>
<td>Mastery-approach hyperlink clicking</td>
<td>.31</td>
<td>.001</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Step 2</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Need for cognition</td>
<td>.21</td>
<td>.01</td>
<td>.26</td>
<td>.007</td>
</tr>
<tr>
<td>Mastery-approach hyperlink clicking</td>
<td>.31</td>
<td>.002</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Need for cognition x Mastery-approach hyperlink clicking</td>
<td>-.08</td>
<td>.378</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The interaction between need for cognition and behavioral traces of mastery-approach goals while studying was not a statistically detectable predictor of achievement ($\beta = -.08, p = .378$), and the incremental variance accounted for by the interaction was trivial ($\Delta R^2 = .01$). While NFC and mastery-approach goals are both positive and statistically detectable predictors of achievement ($p = .007$ and .002, respectively, at step 2), these results do not support the hypothesis that mastery-approach goals are moderated by need for cognition.
Table 13  Summary of Hierarchical Regression Predicting Achievement with Need for Cognition (NFC), Performance-Approach Goals (PAP), and the NFC x PAP Interaction

<table>
<thead>
<tr>
<th>Variable(s)</th>
<th>$R^2$</th>
<th>$\Delta R^2$</th>
<th>Final $\beta$</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Need for cognition</td>
<td>.16</td>
<td>.16</td>
<td>.24</td>
<td>.018</td>
</tr>
<tr>
<td>Performance-approach hyperlink clicking</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Step 2</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Need for cognition</td>
<td>.19</td>
<td>.03</td>
<td>.20</td>
<td>.058</td>
</tr>
<tr>
<td>Performance-approach hyperlink clicking</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Need for cognition x Performance-approach</td>
<td>-.21</td>
<td></td>
<td></td>
<td>.063</td>
</tr>
<tr>
<td>hyperlink clicking</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The regression model predicting achievement as a function of performance-approach goals while studying and NFC suggests a different story. At step 2, all three predictors are statistically detectable at $p \leq .063$ with 19% of variance in posttest achievement accounted for. Despite the convention to use $p < .05$ in testing hypotheses, we should bear in mind Cohen's (1988) advice: Concern over precision of the calculation must not blind us to plausible findings. Thus, in this model, I interpret that NFC does moderate students' expressions of performance approach goals while they study and the interaction between performance-approach goals predicts performance ($\beta = -.21$, $p = .063$).

These results corroborate prior studies that found need for cognition and achievement goal orientation each independently contribute to positively in
predicting variance in academic performance (e.g., Elliot, 2005; Espejo, Day, Scott, & Diaz, 2003). This line of research is extended in two ways. First, I used actual behaviors during studying, rather than self-reports, as indicators of students' goal orientations. Second, I examined the question of whether need for cognition moderated how students manifested their goal orientations as they studied.

My results agree with other research that students high in need for cognition demonstrate better academic performance than those low in need for cognition. As well, I replicated prior findings that approach goals, both mastery and performance, are positively associated with achievement. Need for cognition and goal orientations did not interact as expected in predicting achievement. While need for cognition did moderate students' expressions of performance-approach goals, it did not moderate their expressions of mastery-approach goals.

How can one interpret the negative \( \beta \) coefficient relating achievement to the interaction of need for achievement x performance-approach goals? Briefly, consider the product of need for cognition scores multiplied by trace counts of performance-approach goals. Low scores on both variables yield a small product. High scores on both variables yield a large product. Mid-level scores on both yield mid-sized products. So, a negative \( \beta \) for the interaction indicates that low need for cognition coupled with low performance-approach goals predicts higher achievement; and, high need for cognition coupled with high performance-approach goals predicts lower achievement.
This interaction finding pushes theory into new territory, so I explicitly acknowledge that interpretations are speculations that beg for future empirical investigation. In this light, students with high need for cognition are motivated to engage in frequent, full, and complex cognition. Students with high performance-approach goals seek to demonstrate achievement to others and, theoretically, key their studying activities to what they expect will be tested. If their sense of the test is that it calls mostly for recall of information and some comprehension, their need for cognition is not satisfied if they pursue performance goals that emphasize cognition appropriate to creating low-level cognitive products.

Since there is evidence that they really did pursue performance goals, traced by their choices of hyperlinks clicked, these students may find the interim products of their studying less satisfying – the goals they actually pursue do not afford more complex kinds of cognition that can satisfy their need for cognition. If students are volitionally unable to resolve this tension, they may apply less cognitive effort to studying than they otherwise would, in spite of their high need for cognition. In contrast, students low in both need for cognition and performance approach goals do not experience this tension and may therefore actually engage in more cognitive activity, thereby achieving more.

I suggest two ways to test my hypothesis. First, under an assumption that more cognitive activity requires more time, record time spent studying the information provided at the “destination” of the clicked hyperlink. Time (normalized for reading rate) should be inversely related to the value of the product of students’ need for cognition and performance goal orientation.
Second, invite students to make notes about the information at the “destination” of the clicked hyperlink. Qualitative features of their notes should reveal differences in “forms” of cognitive engagement. The “level” or “depth” of cognitive processing should be inversely related to the value of the product of students’ need for cognition and performance goals.

**Research question 4: Learning pattern analysis**

It is known that major differences exist in the way that novice and expert learners use strategies to acquire and organize information (Carlson, 1990). The introduction of new technologies has encouraged researchers to investigate further what these differences are. A growing volume of research documents learners’ navigation patterns as they read hypertext and how their navigation strategies relate to learning outcomes. The methods of collecting data include video-taping (e.g., Balcytiene, 1999), eye-tracking techniques (Hyönä & Nurminen, 2006), computer monitor transcripts (Horney & Anderson-Inman, 1994), and log files (e.g., Barab, Bowdish, & Lawless, 1997; Barab, Fajen, Kulikowich, & Young, 1996; Niederhauser, Reynolds, Salmen, & Skolmoski, 2000; Sins, et al., 2008).

Most methods for quantitatively analyzing these data take the form of frequency counts of actions that learners perform. Researchers have identified various navigation profiles and, although labels vary, the existence of distinct navigation patterns is supported (e.g., Anderson-Inman, Horney, Chen, & Lewin, 1994; Barab, Bowdish, & Lawless, 1997; Barab, Bowdish, Young, & Owen, 1996; Hill & Hannafin, 1997; Lawless & Kulikowich, 1996; Nesbit, et al, 2007). As
Winne and Perry (1999) and Hadwin (2000) pointed out, SRL is enacted over time through a series of unfolding events. The basic temporal unit of these events is the condition–action, or if–then sequence. Such sequences are not reflected in frequency counts of discrete, static actions. This may provide an importantly incomplete picture of dynamics that constitute SRL in studying. The pattern-based analyses of traces are beneficial to solve these issues.

Niederhauser, Reynolds, and Salmen (2000) investigated strategy patterns to navigate hypertext with the two main measures: the use of hyperlink features and the use of a topic map. Three patterns emerged regarding students’ use of hyperlinks to compare and contrast text content (about constructivist versus behaviorist models of learning). One group frequently used this feature as they read the hypertext. These students consistently moved back-and-forth between the two texts. Another group made minimal use of the compare and contrast feature – they often used the feature at the beginning of a session, and reverting to a linear process after two or three uses. The last group never used this feature. They tended to move systematically through one branch from start to finish, and then go through the second branch. Another set of patterns was also observed based on the topic map. Some students accessed the map frequently and spent considerable time expanding and contracting levels. Some made minimal use of the map, typically opening it once or twice during a session, and spent little time expanding and/or contracting levels. Others never accessed the topic map at all.
In another study, Balcytiene (1999) employed special video technology to obtain data not only on student's nonverbal interaction with the hypertext system but also on their cognitive processes. On the tape, it was possible to see the student's cognitive work on the computer screen (e.g., the mouse movements on the computer screen, different ways of extracting the information), as well as his external behaviour (e.g., the face of the student when carefully reading or thinking). Coupled with stimulated-recall interviews, the detailed analysis of the video material resulted in the discovery of clear differences in the patterns of information access strategies.

Niederhauser, et al.'s (2000) and Balcytiene's (1999) work have made one step forward by taking the learning context into consideration, as reflected by the strategy participants used. Borrowing a tenet in management science, strategy in general will be defined as a pattern in a stream of decisions (Allison, 1971). In other words, when a sequence of decisions exhibits a consistency over time, a strategy will be considered to have formed (Mintzberg, 1978). The same principle applies to learning situations. The learners (or strategy makers) may formulate a strategy through a conscious process before making specific decisions; or, a strategy may form gradually, perhaps unintentionally, as the learners make their decisions one by one. From the chronology of decisions, divided into distinct strategic areas (in the case of learning, for example, the first reading of a chapter, searching external information for better understanding, and reviewing for future test), various strategies could be inferred as patterns in streams of decisions. These strategies could then be examined in conjunction
with each other, as well as with other data such as individual difference variables or contextual factors. There is no need to dwell on the point that strategy formation must be a regular, well sequenced process running through a studying session. Being adaptive is a hallmark of self-regulated learning process. This stream of decisions of certain learning tactic use demonstrates how students define their learning needs, select appropriate learning tactics, and revise their learning strategy to achieve their goals.

When learning is viewed as a constructive process, the learner must strategically access information and relate it to existing knowledge structures (Kozma, 1994). Strategies are forms of procedural knowledge that self-regulated learners voluntarily use for acquiring, organizing, or transforming information, as well as for reflecting upon and guiding their own learning in order to achieve desired outcomes (Alexander, Graham, & Harris, 1998; Weinstein & Mayer, 1986). However, just knowing about cognitive and metacognitive strategies is usually insufficient to promote achievement; students also must be motivated to use the strategies as well as regulate their cognition and effort (Paris, Lipson, & Wixson, 1983; Pintrich, 1989; Pintrich, Cross, Kozma, & McKeachie, 1986). Accordingly, it is important to examine how motivational components covary with strategic decisions when student go about learning in order to describe and understand how personal characteristics are related to students' cognitive engagement and performance. In the next section, the goal-tracing methodology is elaborated with regards to how to locate motivation and learning strategy patterns.
Revisit goal-tracing methodology: Pattern identification

In mathematics, a sequence is a list or linear arrangement of actions, and a subsequence is extracted from the original sequence of actions – a timeline, if you will – by leaving out some of the original detailed actions without disturbing the relative positions of remaining actions that are focal. If a log file for a student is considered a sequence of actions, reconstructing a complete time-referenced description of how each learner studied, then a data-mining algorithm operating on a set of such log files may be able to discover learning patterns that are common to a subset of learners.

To constrain the identification of all possible combinations, a subsequence of all actions logged about studying is deemed a pattern if it occurs more often than a specified threshold specified as a proportion of the sequences (Agrawal & Srikant, 1995). Each pattern represents particular sequences of common learning actions observed to describe students in a group (e.g., an experimental group or a classroom). The algorithm is exemplified in Figure 8, where the letters A to G represent different actions and X and Y stand for two sequences for two learners, respectively. To find the best indicator of the common pattern embedded in multiple sequences, I adopt the longest common subsequence criterion.
Given two sequences X and Y

\[ X = < A, C, B, D, E, G, C, E, D, B, G > \]
\[ Y = < B, E, G, C, F, E, F, B, A > , \]

the longest common subsequence of X and Y is

\[ < B, E, G, C, E, B > . \]

Once action sequences have been identified (parsed), I apply a data mining technique to locate patterns in the sequence of parsed actions. The algorithm uses a bottom-up parsing strategy known as shift-reduce parsing. Basically, this method first attempts to identify the shortest tactics, where a tactic is defined as two or more sequential actions. Then, it infers higher-order structures from lower ones. In real data files, noise and extraneous events would normally halt the shift-reduce parsing process because traditional compilers terminate with failure if an error is detected in the input (i.e., an intruding action). To address this challenge, we designed an adapted shift-reduce parser (Xu, Nesbit, Zhou, & Winne, 2007) that allowed parsing to continue in the presence of noise. The adapted shift-reduce parser works by keeping track of all possible sequences that might involve a certain action. An example of the output is presented in Figure 9.
Here is an example of the process. Consider a list of time-sequenced actions traced about student A within one session: open a learning kit to access the reading material, scroll to continue reading, label the first heading with “Important!”, scroll to continue reading, make a note about the conclusion of one argument, switch between the main window presenting the material and the note window while editing the note, label the note he just made as “Review for midterm,” scroll to continue reading to the end. The events such as kit opening, scrolling, and switching windows are extraneous events for some research questions (but not all). If this is the case, we “tell” the parser to leave out those “noisy events” and focus on parsing the “signal” actions, say, “labeling, note-making, labeling.” After the sequences of all the students in student A's group be
identified, the pattern-miner detects the longest common subsequence within this group. In a large data set, it is usual for sequence modeling to return several hundred common patterns, most of which have no relevance to the researchers’ goals. Therefore, it is necessary for the researcher to be able to search and filter common patterns so that relevant patterns can be more easily identified (Nesbit, Zhou, Xu, & Winne, 2007). In this phase, the software searches for the patterns and counts the frequency of the patterns for each learner (or other unit of observation). These patterns of sequenced actions are then aggregated to infer higher-order structures from them, such as a surface learning approach versus a deep learning approach; or, performance-oriented learning tactics versus mastery-oriented learning tactics. This method allows building up even larger “learning strategies” of how students’ behavior expresses motivation. The data from this phase can be imported to conventional statistical software for further analysis.

Results and brief discussion

First I examined the overall pattern among all the participants in terms of their cognitive tool use. Basically, there were four pattern models of interest at this stage: all labeling; all hyperclicking; first labeling then hyperclicking; and first hyperclicking then labelling (the rest patterns were not considered with multiple shifts between labelling and hyperclicking). A large number of patterns emerged as detected by the pattern finder (Nesbit, Winne, Xu, & Zhou, 2007). When the minimal pattern length was set to 10, and the minimal frequency to 30%, 115 patterns were filtered. Results indicated that, out of 115 identified patterns, a
pattern of LLL...LLHH...H ("L" means labeling and "H" means hyperlink clicking) occurred much more frequently than a pattern of HH...HLLL...L. Undergraduates in my sample were more likely to label the content before clicking the hyperlinks (Figure 10).

Various interpretations might fit these navigation patterns. I speculate about one that illustrates the potential value of pattern-based analyses of trace data. Recall my conjecture about effort required to label (higher effort) versus click a hyperlink (lower effort). First, students changed effort expenditure – more shifted from high to low effort than the opposite. Relative to clicking a hyperlink, which traces an intention to view additional information, labeling could be considered a relatively demanding activity (but not very demanding in an absolute sense) in that the learner must metacognitively monitor content to identify parts of it that correspond to one of the supplied label and deem it worth the effort to label it. Clicking a hyperlink, on the other hand, requires minimal decision making at the time of the click but perhaps some cognitive effort to comprehend the content that is presented at the destination of the link. Students more often shifted from metacognitively-triggered labeling to viewing additional information explicitly labeled for them by the words in the hyperlink than vice versa.

A picture that can be painted using this set of interpretations is that participants in my study were more willing to shift effort to using a tool that didn't require them to metacognitively monitor the content they were studying – clicking a hyperlink that explicitly labeled for them what kind of information they would
find at the link’s destination. Speculatively, this shift in patterns of studying suggests more students became more performance oriented as they worked through the passage we asked them to study in the sense that they preferred not to engage in deeper metacognitive processing of the content on their own but choose to rely on the content to do this metacognitive monitoring for them, in the form of explicit descriptions about information that would be found at the destination of the hyperlink.

Figure 10 Overall sequential patterns graph

Note: “L6H4” indicates a pattern of LLLLLLHHHH (6 label applications followed by 4 hyperlink clicking actions).
Research question 5: Comparisons between high-achievers and low-achievers

Not many studies have examined learning ability as a potential moderator of goal orientations, and these revealed mixed findings. With regard to achievement goal orientation, some researchers have reported that high-achieving compared to low-achieving students scored higher on mastery and performance orientations, and lower on work avoidance tendencies. A tendency was also observed among high-achievers for higher mastery goals than performance goals (e.g., Ames & Archer, 1988; Ee, Moore, & Atputhasamy, 2003). Another study reported that both high and low achievers often adopted an extrinsic motivational stance that favours good grades and rewards and high achievers scored higher than low achievers only in the mastery goal category (Hwang & Vrongistinos, 2002). In contrast to some findings that high-achievers were less performance-oriented but more mastery-oriented (Pintrich & Garcia, 1991; Zimmerman, 1990), one study suggested that students in accelerated classes set lower mastery goals but higher performance goals than peers in normal or delayed classes, and that students in delayed classes consistently reported high levels of work avoidance goals (Bouffard & Couture, 2003).

Researchers have also found differences in academic self-regulation and motivation among low- and high-achieving students. In terms of self-regulatory strategy use, high-achieving students report they actively develop, modify, and transfer strategies to new contexts (Alexander, Carr, & Schwanenflugel, 1995; Bouffard-Bouchard, Parent, & Lareveé, 1993; Hannah & Shore, 1995; Zimmerman & Martinez-Pons, 1990), and perceive they employ more advanced,
effective, and efficient strategies than low-achieving students (Borkowski & Thorpe, 1994; Risemberg & Zimmerman, 1992; Zimmerman & Martinez-Pons, 1990). In contrast, underachieving and low-achieving students appear to be on the opposite end of the continuum. In the view of Krouse and Krouse (1981), the major cause of underachievement is the inability of students to use self-control strategies effectively. It is reasonable to assume that many students who find themselves on academic probation in colleges and universities are students who lack self-regulation.

The current study attempts to offer deeper insights into the nature and individual patterns of self-regulatory strategy use and motivation for using self-regulated learning strategies among low-achieving and high-achieving university students with trace data. This study examined differences of motivation level as well as patterns of learning tactics among undergraduates representing different achievement levels (low versus high achievers) from two different perspectives, specifically, whether consistent differences emerged from self-report responses and actual studying behavior. Rather than being treated as a dependent variable to measure the amount of knowledge the students gained from reading in research question 2, the test score was manipulated as an independent variable under this research question to cluster individuals based on the tendency or disposition of the individual to achieve.

Learning activity comparison

To compare high-achievers’ and low-achievers’ learning activities, I began by standardizing and cluster-analyzing students based on their test scores, using
a k-means approach. This technique partitioned cases into clusters that maximize between-cluster differences and minimize within-cluster variance in test scores (Hartigan, 1975). After requesting three-, four-, and five-cluster solutions, the four-cluster solution was retained to capture the widest distance between groups but also maintain sufficiently large cell-sizes for meaningful analysis. The clusters with the highest and lowest means were identified as high-achiever and low-achiever groups for further analyses. Table 14 displays descriptive statistics for these two clusters in terms of test performance, need for cognition and learning activity variables.

Preliminary analyses examined whether high-achievers reported different types of goal orientations from low-achievers. No statistically detectable differences were observed except for need for cognition ($F = 5.77, p < .05$). With regard to the learning activities logged by gStudy, a MANOVA detected the presence of a significant main effect for the clusters, $F_{(MULTIVARIATE)} = 2.69 (p < .05)$ when 13 learning activity variables were dependent variables. The effect size was $\eta^2 = .505$. Comparison between these two groups showed significant differences in duration, action rate, as well as total number of actions, labels use, and hyperlink use, with high-achievers scoring higher. When label use and hyperlink use were separately examined based on the goal orientation they were coupled with, only hyperlink use showed statistically detectable group difference, with high-achievers displaying more mastery-approach, performance-approach, and performance-avoidance achievement goals. These results are included in Table 14.
Recalling the nearly zero correlations between reported goal orientations and performance, the absence of statistically detectable differences in self-report data between high-achievers and low-achievers was not surprising as the two groups were clustered based on achievement level. The most provocative finding in the present study is that, while high-achievers selected more performance-avoidance oriented labels (such as "Not critical but study for test", "Remember this—others will know it") than the low-achieving counterparts, they did not systematically apply other types of labels more frequently, despite a stronger tendency of using approach labels. In other words, high-achieving students adopted a similar strategy in using labels, which did not contribute to their later performance. Nevertheless, this group exhibited a higher frequency use of mastery-approach, performance-approach, and performance-avoidance hyperlinks.

Scrutiny of students' selection of content being labelled may help explain these conflicting results. Among 275 labels used by high-achievers, 27.59% of them were applied to the text involving the terms with hyperlinks, whereas this only occurred to 19.63% of the labels in the low-achieving group. It is noteworthy that the mean of the number of characters included in the selection was virtually the same across the two groups (Mean = 108.32 for high-achievers; Mean = 108.81 for low-achievers). I speculate that high-achieving students' recognition of the significance of information coincided with the researcher's evaluation or that more high-achievers chose to follow the preset cues (as reflected by hyperlinks) for their studying (see Figure 11).
<table>
<thead>
<tr>
<th></th>
<th>High-Achievers</th>
<th>Low-Achievers</th>
<th>F</th>
<th>p</th>
<th>η²</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(N = 17)</td>
<td>(N = 24)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Mean</td>
<td>Mean</td>
<td></td>
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</tr>
<tr>
<td>Test score</td>
<td>12.29</td>
<td>2.46</td>
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Note: MAP = mastery-approach; PAP = performance-approach; MAV = mastery-avoidance; PAV = performance-avoidance.

Figure 11 High-achievers’ vs low-achievers’ selection of content for label application
Discovering sequential patterns in high-achievers and low-achievers

Pattern-based analyses of trace data also can broaden views about motivational processes that relate to learning. When participants were clustered on the basis of posttest achievement scores into high- versus low-achieving groups, several distinctive patterns were observed in each group (See Table 15): High achievers typically evidenced longer patterns of actions than low achievers. They would sustain a single type of goal orientation throughout the session (mastery-approach or performance-approach); or they tended to oscillate more frequently between patterns that suggest mastery-approach and performance-approach goals, as determined by the semantics of hyperlinks they clicked and the labels they applied while studying. In contrast, low achievers maintained a single shorter pattern throughout the study period representing either performance-approach goals or mastery-approach goals. If they did mix mastery-approach and performance-approach goals, there was just one shift from one orientation to another.

Differences in the length of goal patterns across high versus low achievers indicated less variation in the ways high achievers went about learning. Apparently, the high-achievers either choose to be strongly approach-oriented through the whole studying period or, if they shifted goals, they shifted at a higher frequency. On the other hand, the low achievers demonstrated larger variations in their goal orientations as reflected in the logs of studying. It seems this group was not consistent in using a repeatable strategy, but worked through the material in a less patterned way. Since the high versus low achievement
grouping was based on achievement scores, it is no surprise that a performance-approach goal pattern is associated with better performance. However, these results conflict with current theories in terms of the stability or ubiquity of goal orientation. Specifically, a stable pattern of studying behaviors that expresses mastery-approach goals does not ensure higher achievement, although it might contribute to better understanding of the material. This echoes prior research that mastery goals were unrelated to academic performance but that performance goals predicted graded performance (Harackiewicz, Barron, Carter, Lehto, & Elliot, 1997; Harackiewicz, Barron, Tauer, Carter, & Elliot, 2000, Harackiewicz, Barron, Tauer, & Elliot, 2002). Senko and Miles (in press) further explained that mastery goal learners are more likely to dwell on tangential versus central information to suit his/her own interest. This personal preference does not necessarily accord to teachers’ or test designers’ agendas, which might not lead to better test performance. Instead, a studying pattern marked by shifting between mastery-approach and performance-approach goals yielded more positive achievement. What these differences imply for theorizing about students’ motivations merits further investigation.
Table 15 Learning Sequential Patterns in High-Achievers and Low-Achievers

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<tr>
<td>(2) $L_{MAP} \ 5$</td>
<td>8/24</td>
</tr>
<tr>
<td>(3) $L_{MAP} \ 2 \ L_{PAP} \ 3$</td>
<td>10/24</td>
</tr>
<tr>
<td><strong>High-achievers</strong></td>
<td></td>
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<tr>
<td>(1) $L_{PAP} \ 10$</td>
<td>8/17</td>
</tr>
<tr>
<td>(2) $H_{PAP} \ 9$</td>
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</tr>
<tr>
<td>(3) $L_{PAP} \ 2 \ L_{MAP} \ 3 \ L_{PAP} \ 2$</td>
<td>8/17</td>
</tr>
<tr>
<td>(4) $L_{MAP}^1 \ H_{MAP} \ 1 \ H_{PAP} \ 2 \ L_{MAP}^1 \ H_{PAP} \ 3$</td>
<td>8/17</td>
</tr>
</tbody>
</table>

Note: "$L_{MAP}^2 H_{PAP}^3$" indicates a pattern of $L_{MAP} L_{MAP} H_{PAP} H_{PAP} H_{PAP}$ (2 mastery-approach label applications followed by 3 performance-approach hyperlink clicking actions).
A goal of this research was to apply a new kind of methodology to investigate the process of knowledge construction. The literature on achievement motivation converges on the conclusion that a person's goals can influence his subsequent behavior (e.g., Dweck, 1996; Gollwitzer & Moskowitz, 1996; Grant & Dweck, 1999; Thiede, 1996). Thus, the prime thrust of my research has been to identify how achievement goal orientations covary with learning behaviour during learning processes. The exploratory studies reported here constitute a limited database, but they do call into question a number of assumptions about the process, particularly the operational definitions of goal orientation and learning strategy.

In light of salient limitations of self-reports, I used computer logs to track students' learning behavior as well as their goal orientations traced operationally using labels and hyperlinks. Traces provide relatively more direct and reliable indicators of mental activities. A unique feature of tracing is that researchers are able to develop a dynamic account of an individual's thinking in relation to an evolving work, e.g., reading within a given period of time. Compared to self-reports, traces reduce or eliminate: a learner's mediation of researchers' instructions, post hoc searches of memory and mental calculations needed to rate or characterize what is retrieved about a learning tactic or a learning goal.
Compared to think-alouds, traces do not interrupt the flow of cognition while the learner describes an event. Further, traces standardize how a cognitive activity is coded into an observable representation (Jamieson-Noel & Winne, 2003) without substantially interfering with how students engage in studying and construct knowledge. Trace methodology counters some concerns about concurrent think-aloud protocols, free descriptions, and self-report questionnaires with respect to challenges these methods face in capturing mental activities (such as goals) and providing raw materials for building theories about learning processes (Winne, 2006a; Winne, Jamieson-Noel, & Muis, 2002).

Using the goal-tracing methodology developed for this research, some findings replicated prior studies and some did not. First, my research corroborated again the low correspondence between students' perceptions about themselves regarding how they go about learning and what they do when learning. Evidently, the assumption that people are able to provide valid reports of these predispositions can be questioned in the light of evidence about the nature of self-reports on mental processes. Surveys on student learning require respondents to provide cumulative and retrospective accounts of how they conduct academic tasks, and it is unlikely they have retained an accurate record in long-term memory of the mental activities that were involved. In this case, their accounts are likely based, at least in part, on inferences and reconstructions derived from their subjective and implicit theories of the mental processes involved (Ericsson & Simon, 1980; White, 1989).
This suggests two important points. One is that complete reliance on self-reporting would jeopardize the reliability of scientific research. This could be even more serious when research participants are younger children. Other than the possibility that children struggle with the language and response formats (rating scales) used on many self-report measures (Cain & Dweck, 1995), they might also have difficulty generalizing across tasks and over time to evaluate what is their "typical" approach to given situations (Turner, 1995). Often they conflate intentions with actions; namely, if their intention was to try hard, follow directions, and do good work, ipso facto, they believe they have done good work (Paris & Newman, 1990). This leads to the second point that more individual characteristics and contextual factors should be considered when developing questionnaires with the aim of enhancing the accuracy of responses. Situations described in each item need to be designed in a way that respondents are released of taxing search in memory and making possibly distorted inferences.

Subsequent analyses I carried out investigated a widely researched question: How do learning activities and motivation relate to achievement? The major difference between my work and prior research is the direct comparison between self-reports and trace data with regards to which is more powerful in predicting achievement. Not surprisingly, the behavioral measures (through labels) of achievement goals showed stronger correlations with test performance. In previous literature, self-report goal orientations were observed to be correlated with academic performance, under the assumption that a series of learning
activities would occur as a function of particular goal adoption, which led to better performance.

When need for cognition was brought into consideration, the negative β coefficient relating achievement to the interaction of need for achievement x performance-approach goals pushes me to reconsider current motivational theories. Scholars previously embraced the notions that expert learners would (a) spend time thinking about the task (need for cognition), (b) attempt to understand the learning and draw meaning from it (deep approach), and (c) select appropriate strategies (adaptive control) in order to accomplish this (e.g., Schoenfeld, 1987). However, a higher level of need for cognition might run the risk of exhausting learners’ limited mental resources for cognitive and metacognitive processing, particularly when they aimed for a higher mark. This could partially explain why high need for cognition coupled with high performance-approach goals predicts lower achievement. On the other hand, experimental studies have also indicated that learners with low need for cognition people can engage in effortful processing when the social context requires it (Cacioppo et al., 1996), which cannot be captured by self-reporting. This clarifies a possible reason for why low need for cognition combined with low performance-approach goals predicts higher achievement. This also highlights the need to develop behavioral measures of need for cognition in future work.

The essence of the goal-tracing methodology is highlighted in the subsequent pattern-based analyses of learning processes. The identified patterns were shown to be not very complex in the sense that only approach-
oriented goals were identified, and not many shifts were observed between
different types of goal orientations. Considered together, the results support both
a single-goal and multiple-goal model, in which adopting either performance-
approach goals alone or mastery and performance approach oriented goals
together can facilitate performance in university students. This suggests that the
participants in this study by and large were interested in understanding the
reading material and wished to perform well on the test. I suspect this was
associated with the laboratory settings where the study took place, with
reminders of taking a posttest after reading. In spite of no explicit promotion of
approach goals, the participants might assume that their task was to prepare for
the posttest. Future research is necessary in authentic classrooms with real
learning tasks and credit-bound grades.

Literature has identified four characteristics in strategic learners: (a) They
critically assess tasks, such as studying a textbook chapter, to identify features
that may influence how they engage with the task and the degree of success
they will have. (b) On the basis of their assessment, strategic students define
short-term goals and probably overall goals for studying. (c) They are aware of
alternative cognitive tactics that provide options about tactics to apply to
studying. And, (d) they make judgments about which tactic(s) or pattern(s) of
tactics has the greatest utility for achieving the goals they choose to pursue
(Hadwin & Winne, 1996; Winne, 1995, 1997; Winne & Hadwin, 1998). Thus, two
major tasks, promising but challenging, are to be accomplished in future
explorations. One is that each component involved in the pattern is tagged with
contextual attributes (e.g., which part of the chapter being annotated; what stage in the reading session a tactic was applied, etc.). This quantifying process would inevitably lose certain information such as mental activities that were not translated into behavior, so it is still a leap to depict learning as a process (as opposed to a product). Following this lead, the second task is to detect typical patterns for strategic learners: What information was processed before approaching a given task? What type of study tactics was employed? In what context these decisions were made? What triggered the change of particular tactics. And so forth.

**Methodological implications and limitations**

Because there was little precedent for my research and because the process of learning is likely extremely complex, it was evident at the outset that my research would have to be exploratory and inductive. In my view, this study is distinguished from previous studies in that the tracing methodology I employed implements another method for examining self-regulated learning processes. As noted in recent reviews of methodological issues related to these and other types of measures (see Winne et al., 2002; Winne & Perry, 2000), questionnaires studies can ascertain how often students report self-regulating behaviours; nonetheless, they cannot characterize what students actually do to study. The event-based traces about students' goal adoption provide a unique lens through which I could track and assess more fully and accurately how students' motivation varied in terms of goals they were pursuing.
The factor analysis revealed that goal-oriented hyperlink-clicking actions did not track learners' goal orientations successfully whereas label applications did. As discussed earlier, the effort-minimizing action of clicking a hyperlink did not require learners to engage in deeper thinking as to why a certain hyperlink was chosen over another (although in some cases the result of deeper thinking could lead to clicking all the available hyperlinks). This limits evidence about learners' true intentions behind this action. In contrast, when students selected a portion of the content, choosing a label clearly defines the type of goal(s) held in this micro-context. Thus, this labeling goal-tracing methodology is promising for future research as a method for operationalizing motivational constructs, but researchers should ensure traces can be cross-validated.

Critical consideration of this method should convince one that it does not offer a perfect solution to the problem. It should be noted first of all that the names I constructed for labels and hyperlinks need further revision to increase validity in relation to theoretically proposed dimensions of goal orientation. For instance, the label invented for performance-avoidance achievement goals, "Not critical-but study for test," might be refined in that information considered unimportant would have less chance to be studied.

Also, data were collected only in a single assigned task, and analyses include only volunteers who used gStudy for only one hour. Although students were given multiple opportunities to demonstrate their goal orientations, which provided one mechanism to ensure internal validity, inferences based on trace data may be event specific and might not generalize beyond the particular
context wherein students generate traces. Moreover, trace data likely constitute a sample of cognitive events rather than a complete representation of a population of them in that some cognitive acts may not necessarily be expressed overtly (Jamieson-Noel & Winne, 2003). This was overcome to a certain extent in the present study as the goal expressions were linked directly to the action students performed. Only when students acknowledged the titles of the labels and hyperlinks did they select the tool to annotate the text.

Also, participants' prior knowledge level of the topic was not controlled. Although the background information (major area of study) provided me with information of their specializations, this does not allow me to see whether their prior knowledge in the topic (hypnosis) is a possible confound in explaining the post-test performance; nor can I determine how participants used prior knowledge while studying. Intuitively, students who already know this topic thoroughly might not be active in using cognitive tools yet would master the material and outperform others. In addition, high-achievers evidently spent much longer studying the chapter, which might again threaten the validity of the findings.

Conclusions and future directions

The potential for computer-based tools to boost learning remains high, although the current contribution of technology to research innovation is exasperatingly difficult to demonstrate. Winne (2006) called for software tools to genuinely support students as well as researchers in their respective tasks of researching how to make learning effective. Recent advancements in technology
have broadened opportunities for measuring important processes involved in learning. Multimedia learning tools like gStudy offer promise to meet this call. gStudy's log data provides a bridge to join students' perceptions about goals with traces that reveal how they seek goals. My results indicate that traces recorded by gStudy indicate the motives, preferences and decisions that characterize learners' SRL. It allows educators as well as researchers to gain insights into students' implicit goals. As well, trace methodology counters concerns about the reliability and validity of concurrent think-aloud protocols, free descriptions, and self-report questionnaires with respect to representing dynamic mental activities that are theoretically sensitive to unstable conditions during learning (Winne, 2006a; Winne, Jamieson-Noel, & Muis, 2002).

In 1992, Green made a claim that "What is required is a more sophisticated approach to conceptual analysis in general. Phenomena such as learning, memory, reasoning, perception and emotion can be neither adequately defined in terms of, nor reduced to, a small set of measurement operations" (p. 315). Although traces can be difficult to gather, analyze and interpret as indicators of learning tactics and strategies, they have potential as an alternative to self-reports which are more prone to misjudgement and errors of recall. Thus, analyses of traces in log files and the patterns they represent have potential to contribute to a fuller picture of learning processes that may more completely characterize what is "going on" during learning.

Although we are beginning to understand to some extent how learners go about learning and how their motivation fluctuates, sufficient attention has not
been paid to strengths and weaknesses of different operational definitions for psychological constructs. Self-report is essential because these are the data that learners have "in mind" when they engage in self-regulated learning. Yet, to provide a fuller account of how learning and motivational processes entwine and change over the course of learning, we need to augment these methods with techniques that are sensitive to dynamic manifestations of psychological engagement during complex learning activities. Tracing methodology takes promising steps toward this goal of capturing such dynamic learning process and advancing educational research. Beyond the forgoing suggestions, I forecast three potentially useful areas of future research.

An obvious next step in developing this methodology involves mapping a variety of motivational factors onto patterns of actions taken in the course of learning. If a correspondence emerges between motivation patterns and patterns of actions, then predictions may be made about motivation based on actions collected on-the-fly. This brings theorizing closer to the phenomena it seeks to explain. Due to inevitable conceptual ambiguities in some motivational constructs (such as goal orientation), the mapping between motivation patterns and patterns of actions should have an empirical as well as a rational or logical basis. Future work should collect more empirical data to test this methodology, as I attempted to do.

Second, more explorations is needed regarding the cross-validation of identified patterns. Rather than stipulating what particular goal students hold a priori, my approach was to explore goal types based on traces of students'
actions logged while they studied within gStudy. The process of analysis has two phases analogous to the exploratory and confirmatory phases in factor analysis. In the exploratory phase the problem is to use one data set to discover the action patterns that correspond to adopted goal. Once one completes the exploratory phase and finds patterns in the data based on theoretically plausible interpretations (this allows that current theories could be supported or not), the research can proceed to a confirmatory pattern-matching phase. In the confirmatory phase, the problem is to show that the discovered action patterns are evident in other data sets examining the same research question. That is, a split sample cross-validation technique is adopted. Once patterns have been identified they can be counted and statistically analyzed like other data.

Finally, traces of goals are not confined to the methods I reported here. More behavioral indicators of achievement goals should be developed. One illustration of this call is the well-regarded trace of intrinsic motivation represented by persistence with an unsatisfying experimental activity when enticing external contingencies are withdrawn (for a review, see Cameron & Pierce, 1994.) I urge researchers to continue to explore for other behavioral records/traces and test the justification of each to bridge the gap between theory and empirical observation. To track learners' conceptual and motivational development as accurately as possible, the trace data should be triangulated using other kinds of data. I believe this "thick description" can provide multiple levels of integrated information about learners' attitudes, beliefs, and interactions with the content.
All of these future areas of research would add to and complement current research in achievement goal orientation. As researchers, we do not know enough about the interplay between different contexts and how students react to those elements via their goal adoption. Moreover, we do not know enough about how students adapt their goal choice when they realize potential problems, risks or any mismatch (e.g., their original goals are not being met). Future research in these areas would lend credence to current goal models or perhaps enhance them to more fully understand properties that impact both learning and achievement.
APPENDICES

Appendix A  Consent Form and Demographic Form

SIMON FRASER UNIVERSITY

Informed Consent by Participants in a Research Project

This research is being conducted under permission of the Simon Fraser University Research Ethics Board. The chief concern of the Board is for the health, safety, and psychological well-beings of research participants.

Should you wish to obtain information about your right as a participant in research, or about the responsibilities of researchers, or if you have any questions, concerns or complaints about the manner in which you were treated in this project, please contact the Director, Office of Research Ethics by email at hweinber@sfu.ca or phone at 604-268-6593.

This project is investigating the operationalization of goal orientation and learning strategy. The purpose of this project is to employ tracing methodology to operationalize learning behavior.

Participation involves the agreement to release your personal information (age, gender, and educational background), posttest scores, questionnaire responses as well as the logged learning events during the study session for research purposes.

If you choose to participate, you can withdraw at any time. The information you provide will be kept confidential to the full extent permitted by the law. Your anonymity will be protected in any published reports.

Your signature on the other page of this form will signify that you have read the description of the procedure and benefits of this research project, that you have received an adequate opportunity to consider that information, and that you voluntarily agree to participate in the project.

Project: Operationalizing and Tracing Goal Orientation and Learning Strategy
Investigator: Mingming Zhou
Department: Faculty of Education
I understand that I may withdraw my participation at any time and may register any complaint with the Director of the Office of Research Ethics, the Dean of the Faculty of Education, or the investigator (Mingming Zhou). I may obtain copies of the results of this project upon its completion by contacting mzhou2@sfu.ca.

Benefits: Participation in this project will contribute to improvement in goal theory and research methodology in the field of self-regulated learning (SRL). Participants will obtain feedback on their individual learning patterns once they express interest.

Risks: No risks have been identified.

I agree to the following (check if appropriate):

- Release to the investigator: test scores, questionnaire responses, and learning kit log file data.
- Gratuity: 15 CAD cash for the participation.

Having been asked to participate in this research project, I certify that I have read the description of the procedures and I understand the procedures to be used in this project.

The subject and witness shall fill in this box (Please Print Legibly)

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Contact Information

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First Language | Degree
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<td>Degree</td>
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Major

Signature

Date
Appendix B  Achievement Goal Questionnaire

In the following questionnaire indicate the extent to which each item is true of you. If you think the statement is very true of you, circle 7. If a statement is not at all true of you, circle 1. If the statement is more or less true of you, circle the number between 1 and 7 that best describes you.

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<td></td>
<td>not at all true of me</td>
<td></td>
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<td></td>
<td></td>
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<td>very true of me</td>
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1. It is important for me to do better than other participants.  
2. In this experiment, I want to avoid getting a lower score than other participants.  
3. I want to learn as much as possible from this article.  
4. My goal in this experiment is to avoid performing poorly.  
5. It is important for me to do well compared to other participants in this experiment.  
6. I worry that I may not learn all that I possibly could in this article.  
7. I just want to avoid doing poorly in this experiment.  
8. It is important for me to understand the content of this article as thoroughly as possible.  
9. I am often concerned that I may not learn all that there is to learn in this article.  
10. I desire to completely master the material presented in this experiment.  
11. Sometimes I'm afraid that I may not understand the content of this article as thoroughly as I'd like.  
12. My goal in this experiment is to get a better score than most of the other participants.
## Appendix C  Need for Cognition Scale

In the following questionnaire indicate the extent to which each item is true of you. If you think the statement is very true of you, circle 7. If a statement is not at all true of you, circle 1. If the statement is more or less true of you, circle the number between 1 and 7 that best describes you.

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1. I would prefer complex to simple problems.
2. I like to have the responsibility of handling a situation that requires a lot of thinking.
3. Thinking is not my idea of fun.
4. I would rather do something that requires little thought than something that is sure to challenge my thinking abilities.
5. I try to anticipate and avoid situations where there is likely chance I will have to think in depth about something.
6. I find satisfaction in deliberating hard and for long hours.
7. I only think as hard as I have to.
8. I prefer to think about small, daily projects to long-term ones.
9. I like tasks that require little thought once I've learned them.
10. The idea of relying on thought to make my way to the top appeals to me.
11. I really enjoy a task that involves coming up with new solutions to problems.
12. Learning new ways to think doesn't excite me very much.
13. I prefer my life to be filled with puzzles that I must solve.
14. The notion of thinking abstractly is appealing to me.
15. I would prefer a task that is intellectual, difficult, and important to one that is somewhat important but does not require much thought.
16. I feel relief rather than satisfaction after completing a task that required a lot of mental effort.
17. It's enough for me that something gets the job done; I don't care how or why it works.

18. I usually end up deliberating about issues even when they do not affect me personally.
Appendix D  Posttest Questions

There is only one correct answer for each question. Circle the letter that matches your answer.

1. What are possible uses of hypnosis in real life?
   A. Helping people remove bad habits
   B. Improving learning
   C. Facilitating imagination
   D. Playing role-playing game

2. What is the perceptual effect of hypnosis like on hypnotized subjects?
   A. The subjects lose their mind.
   B. The subjects respond to commands from the hypnotist in ways that seem automatic and involuntary.
   C. The subjects ignore very loud noises.
   D. The subjects fall into sleep.

3. According to this article, which of the following three statements discount(s) the claim that hypnosis can dramatically improve recall?

   I. It is hard to judge whether memories recovered during hypnosis are accurate representations of what actually occurred.
   II. Hypnosis induces people to dream about something that has not happened.
   III. The hypnosis induction creates supportive environments in which to remember.

   A. II. and III.
   B. I. and III.
   C. All of them
   D. I. only

4. Hypnotized subjects were asked to submerge one arm into cold water and told “You will be aware of no pain, but that other part of you, which is aware of everything going on, can signal any true pain by pressing this key.” Then, subjects pressed this key repeatedly—reporting the pain—and the key presses became more frequent the longer the arm was kept submerged. Which term describes this experiment best?

   A. Unconsciousness
   B. Hidden Observer
   C. Dissociation
   D. Awareness

5. Which topic on hypnosis is NOT controversial?
   A. Hypnosis is characterized as a splitting of consciousness.
B. Subtle suggestions are critical to induce hypnosis.
C. Hypnosis is effective to enhance memory.
D. How to explain the phenomena of hypnosis.

6. The observation that a person can hold a limb of the body in a rigid position for long periods without tiring shows what type of effect of hypnosis?

7. Give an example to demonstrate the hypnotic hypermnnesia phenomenon.

8. What makes age regression differ from thinking about the past?

9. What is the relevance of "dissociation" to hypnosis?

10. Make up experiment results which would contradict the social role playing interpretation of hypnosis.
Appendix E Chapter

The Phenomena of Hypnosis

A variety of methods can be used to induce the hypnotic state. The most popular technique is one where the hypnotist, acting as an authority figure, suggest to the client that he or she is growing increasingly more relaxed and sleepy with time: "Your eyes are getting heavier and heavier, you can barely keep your lids open," and so on. Often the client is asked to fixate on something, perhaps a spot on the wall or a swinging pendulum. The logic here is that eye fixation leads to muscle fatigue, which helps convince clients that they are indeed becoming increasingly relaxed. Other approaches to induction rely more on subtle suggestions (Erickson, 1964), e.g., HILD\(^1\) (Hypnosis Induced Lucid Dream), but in general no one method is necessarily better than any other. In the words of one researcher, "The art of hypnosis relies on not providing the client with grounds for resisting (Araoz, 1982, p. 106).

Once they are hypnotized, a person becomes highly suggestible, responding to commands from the hypnotist in ways that seem automatic and involuntary. The hypnotist can then use his or her power of suggestion to achieve adaptive ends, such as helping people kick unwanted habits like smoking or overeating. Anaesthetic effects\(^2\) are also possible at certain deep stages of hypnosis, e.g., suffering less pain during childbirth (Harmon et al., 1990), during dental work (Houle et al., 1988), even for major surgeries (e.g., appendectomies) (Kihlstrom, 1985). It was once thought that the release of endorphins by the brain might be responsible, although this possibility now seems less likely (Moret et al., 1991). Catalepsy is an impressive demonstration, wherein the subject can hold one or more limbs of the body in a rigid position for long periods without tiring. Perceptual effects\(^3\) are also common. The hypnotized volunteer in the experiment, acting as kind of robot, appears to see or hear things that are not really there; perhaps the subject carries on conversation with imaginary people or ignores loud noises that would normally cause someone to jump.

Memory Enhancement

One frequent claim is that hypnosis can dramatically improve memory, a phenomenon called hypnotic hypermnesia. "Hypermnesia" refers to an abnormally vivid or complete memory. Hypnotic hypermnesia\(^4\) is the belief that hypnosis enhances accurate memory for events that a person is initially unable to remember. Perhaps you have heard of criminal cases where hypnotized witnesses suddenly and miraculously recalled minute details of a horrific crime. In one famous kidnapping case from the 1970s, a bus driver was buried 6 feet underground along with 26 children inside a tractor trailer. Later, under hypnosis, he was able to reconstruct details of the kidnapper's license plate – digit by digit. Hypnosis is sometimes used therapeutically to recover forgotten traumatic incidents\(^5\). There is a long-standing belief among many psychotherapists that hypnosis is an excellent tool for uncovering hidden memories of abuse or other
forms of psychological trauma (Yapko, 1994). This helps establish evidence of the incidents and resolve the traumatic memories.

Unfortunately, there is little hard evidence to support these phenomena scientifically. A patient's memory may indeed improve after a hypnotic session, but this fact does not allow us to conclude that the hypnotic state was responsible for the improvement (Spiegel, 1995). One possibility is that the hypnotic state induction procedures (the relax techniques) simply create effective and supportive environments in which to remember (Geiselman et al., 1985). Another problem is that it is often difficult to judge whether memories recovered during hypnosis are, in fact, accurate representations of what actually occurred. You may "remember" a particularly unfortunate experience from the 2nd-grade classroom, but can you be sure that this traumatic episode indeed occurred as you remember it? Also, what appear to be memories are sometimes fabrications—stories that the subject unintentionally makes up to please the hypnotist. For this reason, many states have banned the use of hypnotic testimony in criminal court cases.

There have even been a number of well-publicized examples of age regression under hypnosis, in which the subject mentally travelled backward to some earlier place and was able to recall numerous details. It is to be distinguished from thinking about the past, or remembering it: the age regressed person experiences being a younger age in a subjectively vivid and compelling manner, and this is accompanied, quite often, by what appear to be age appropriate changes in voice, mannerisms and handwriting. Although the age regressed person's behavior can be very convincing subjectively, that is no guarantee of the historical accuracy of anything that a person recalls about his/her past during age regression.

**Explaining Hypnosis**

Even if a hypnotized person is experiencing some kind of altered form of consciousness, there is considerable debate about exactly how this so-called state should be explained.

**Hypnotic Dissociations**

Some researchers have argued that hypnosis produces what are called hypnotic dissociations in the subject. By "dissociations", it is meant that the individual experiences a kind of splitting of consciousness where multiple forms of awareness coexist (Hilgard, 1992). Hilgard (1986) has argued that conscious awareness in a hypnotized subject is actually divided into separate components. One stream of consciousness follows the commands of the hypnotists, perhaps feeling no effects of painful stimulation, while another stream, the hidden observer, is painfully aware of the true stimulation. His position is supported with experiments in which hypnotized subjects are asked to submerge one arm into a bucket of cold ice water. "You will be aware of no pain", the subjects is told, "but that other part of you, the hidden part that is aware of everything going on, can signal any true pain by pressing this key." It turns out that people press this key repeatedly—reporting the pain—and the key presses become much more
frequent the longer the arm is kept submerged. During hypnosis, as well as afterward, the subjects claim to have no knowledge of what the non-submerged hand is doing; there is a hidden part of consciousness that maintains realistic contact with what is going on.

This idea that conscious awareness is divided or split during hypnosis may seem mystical, strange, and worthy of skepticism. But the brain often divides its labour to arrive at adaptive solutions. You walk and talk at the same time, and you certainly do not consciously think about picking up each leg and putting it down while making a point in the conversation. The idea that consciousness is regularly dissociated, or divided, is not really an issue to most psychologists; it is accepted as a given, as a normal part of psychological functioning. But whether it is correct to characterize hypnosis as a true splitting of consciousness is still a matter of debate.

**Social Role Playing**

Most of the skepticism about hypnosis comes from the fact that hypnotic behavior may, in fact, simply be a kind of social role playing. Hypnotized subjects have not actually lost voluntary control over their behavior; rather, they follow the lead of the hypnotist and obey his or her every command because they think, perhaps unconsciously, that involuntary compliance is an important part of what is means to be hypnotized (Lynn et al., 1990). For example, if people are told prior to being hypnotized that a rigid right arm is a prominent feature of the hypnotized state, then rigid right arms are likely to be reported after hypnosis even when no such specific suggestion is made during the induction process (Orne, 1959). Everyone has some idea of what hypnotized behavior looks like — to be hypnotized, so when people agree to be hypnotized, it often appears as if subjects are trying desperately to “do whatever they can to achieve the suggested effects” (Kihlstrom & McConkey, 1990). One compelling finding that supports this role-playing interpretation is that essentially all hypnotic phenomena can be reproduced with stimulated subjects — people who are never actually hypnotized but who are told to act as if they are hypnotized as part of an experiment (Spanos, 1986).

1Click to

avoid misunderstanding about this

**HILD (Hypnosis Induced Lucid Dream)** is an approach used to induce people into a hypnotic state by reinforcing subtle suggestions.

find more info about this

Lucid dreaming is basically dreaming while being aware that you are dreaming. If you are in a lucid dream, you will usually have some power over your dream — anything from being able to fly or making a room appear inside a pocket to being able to change into animals and create a whole world!
Hypnosis is working with your subconscious and dreams are your subconscious’ world. Hypnosis Induced Lucid Dream (HILD) is to induce a large amount of long, vivid, highly lucid dreams in a short amount of time.

HILD is the acronym for Hypnosis Induced Lucid Dream. It is an approach to induce hypnosis.

Fill-in-Blank Exercise: Common hypnosis induction techniques are: suggesting people that their eyes are getting heavier and heavier, asking people to fixate on something, and _________.

Which of the following is NOT an example of anaesthetic effects of hypnosis?
A. Removing people’s bad habits
B. Suffering less pain during surgeries
C. Catalepsy
D. Dreaming about future

Stern et al.’s (1977) comparative study found that, among hypnotizable people, the effect of hypnosis was superior to morphine, diazepam, aspirin, acupuncture, and biofeedback (See the figure). Hypnosis induction relieves both sensory pain and suffering a lot.

Anaesthetic effect is a major effect of hypnosis, which indicates that hypnosis can effectively relieve pain from burns, cancer, childbirth, and dental procedures.
A major effect of hypnosis is anaesthetic effect. Perceptual effects concern human perception change under hypnosis. Basically, hypnotized people see or hear things that are not what they really sense.

In 2000, Spiegel and others conducted experiments wherein subjects were asked to view pictures in both color and grayscale. When hypnotized subjects were told they would see photos in color, they would admit they saw color photos because the brain regions involved in the visual processing of color were activated, even if the subjects were actually viewing the grayscale photos. And when hypnotized subjects were told they would see photos in grayscale, the activation of the color processing regions decreased. The subjects would report they saw grayscale photos, regardless of which photos actually appeared.

Another effect of hypnosis is perceptual effects. Please give an example of perceptual effects of hypnosis.

Hypnotic hypermnesia is a term referring to another effect of hypnosis - improving memory. How do you define "hypnotic hypermnesia"?

Hypnotic hypermnesia suggests that people can recall past forgotten (details of) events that are not supposed to be recalled in normal circumstances.

Although a long tradition exists suggesting that hypnosis can enhance memory (hypnotic hypermnesia), the experimental literature is quite mixed. Recent laboratory studies show that true memory enhancement (hypermnesia) exists. However, it is repeated retrieval effort and not hypnosis that is responsible for hypermnesia: Repeated testing without hypnosis yields as much hypermnesia as with hypnosis.
In a case study in 1993, hypnosis incorporating images of competence and efficacy was utilized to assist a young woman to overcome feelings of powerlessness that were engendered by childhood sexual abuse. This treatment was highly effective in assisting this patient to resolve her traumatic memories of these episodes of molestation and abuse.

Hypnosis sometimes arouses memories of bad events in life.

True or False Question: Hypnosis is only effective to arouse bad memories of past events.

This statement suggests that hypnosis can also be a therapy tool to deal with traumatic memories.

It is important to know that there is little scientific evidence to be found to support the memory-enhancing effect of hypnosis.

Summarize the claims made in this article that deny the memory-enhancing effect of hypnosis.

Scientifically, those anecdotal reports (like the above story) have not been duplicated under laboratory conditions. Research has largely failed to find evidence that hypnosis can enhance memory performance.

A 1994 report by the Committee on Techniques for the Enhancement of Human Performance concluded that gains in recall produced by hypnotic suggestion were rarely dramatic, and were matched by gains observed even when individuals are not hypnotized.

Which of the following exemplifies the concept of "age regression"?

A. Recently, I think of my graduation ceremony in high school very often.  
B. Sometimes when I thought about my childhood when I was playing games with my friends, I started to behave like a small boy.  
C. I often dream about the moment I become an Olympic champion.
D. Even now I am an adult, I can still remember part of my childhood vividly.

*avoid misunderstanding about it*

Age regression means a person can mentally go back to his early days and be able to recall the events in those days.

*see an example of this*

Orne (1951) reports the case of a German-born experimental subject, regressed to age six, when he spoke no English. Figure A is the drawing that he had made at that age of 6, compared to the one he made in the experiment when hypnotically regressed to age six (Figure B).

![Figure A. Original drawings at age 6.](image1)

![Figure B. Drawings done when age regressed to 6.](image2)

*avoid forgetting this in test*

Age regression is an important concept related to memory performance under hypnosis.

*8Click to*

*find out what this metaphor means*

The "hidden observer" is a metaphor for dissociation to indicate that ideas could be cut off, or detached from the mainstream of consciousness. It is a part of everyone's consciousness. While under hypnosis, it monitors what is going on, and measurable pain that does not register in conscious awareness must register at a covert "hidden" level, which is somehow dissociated from the mainstream of consciousness.

*avoid forgetting this in test*

The hidden observer is an important concept that describes why hypnotized people can still feel pain.
Fill-in-Blank: If consciousness can be split into two parts, one part is unaware of the pain, while the other part can feel the pain. The latter is also named as _.

Hidden observer is a metaphor to indicate the part of human consciousness, which is aware of pain even when hypnotized.

The social role playing theory suggests that the subject acts in accordance with expectations of the hypnotist and hypnotic situation and behaves in the way he or she thinks a hypnotized person would behave.

True or False: The social role playing explanation of hypnosis still considers how people's consciousness is altered during hypnosis.

Hypnosis is a learned behavior, according to Spanos, an issue out of a socio-cognitive context. This view states that the observed effects of hypnosis are the result of the subject's fulfilling the role of how they think a hypnotized person would act rather than an actual change in the state of consciousness. It has nothing to do with exercising control over the subject's subconscious mind. In short, what is called hypnosis is an act of social conformity rather than a unique state of consciousness.

The social role playing theory is a different perspective from dissociated consciousness theory to explain hypnosis.

Psychologists use stimulated subjects to seek evidence to support the role-playing interpretation of hypnosis.

Stimulated subjects refer to those who are never actually hypnotized but who are told to act as if they are hypnotized.

Which of the following experiment methods would be the most suitable for the role playing interpretation of hypnosis?

A. Detecting how brain-waves change during hypnosis
B. Using stimulated subjects
C. Interviewing subjects after the experiment

D. Conducting the experiment on the same sample repeatedly

Stam and Spanos (1980) found that, when treatment demands called for high levels of pain reduction, subjects spent a good deal of time engaged in coping imagery and they reported low levels of pain. When implicit demands did not call for large pain reduction, subjects engaged only minimally in coping imagery and reported high degrees of pain. These findings underscore the important role of contextual factors in guiding subjects' interpretations of the test situation as well as the role of motivational factors in leading subjects to perform consistently with those expectations.
Appendix F  Latin-square Games

Instruction:

Fill in the grid so that every row, and every column contains all digits 1-6 only once. You will have only 8 minutes to finish all these three tasks.

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