Open Access

You Cannot Have Your Cake and Eat It, too: How Induced Goal Conflicts Affect Complex Problem Solving

Christine Blech* and Joachim Funke

Psychologisches Institut, Universität Heidelberg, Hauptstraße 47-51, D-69117 Heidelberg, Germany

Abstract: Managing multiple and conflicting goals is a demand typical to both everyday life and complex coordination tasks. Two experiments (N = 111) investigated how goal conflicts affect motivation and cognition in a complex problem-solving paradigm. In Experiment 1, participants dealt with a game-like computer simulation involving a predefined goal relation: Parallel goals were independent, mutually facilitating, or interfering with one another. As expected, goal conflicts entailed lowered motivation and wellbeing. Participants' understanding of causal effects within the simulation was impaired, too. Behavioral measures of subjects' interventions support the idea of adaptive, self-regulatory processes: reduced action with growing awareness of the goal conflict and balanced goal pursuit. Experiment 2 endorses the hypotheses of motivation loss and reduced acquisition of system-related knowledge in an extended problem-solving paradigm of four conflicting goals. Impairing effects of goal interference on motivation and wellbeing were found, although less distinct and robust as in Experiment 1. Participants undertook fewer interventions in case of a goal conflict and acquired less knowledge about the system. Formal complexity due to the interconnectedness among goals is discussed as a limiting influence on inferring the problem structure.

Keywords: complex problem solving, goal conflicts, motivation, system knowledge, strategy.

INTRODUCTION

You cannot have your cake and eat it, too. One of the possibly best-known goal conflicts is delivered by a proverb. Similar common sayings across other languages exist, marking conflicting strivings an intercultural or even universal phenomenon. Examples from everyday life are abundant: working overtime in order to qualify for a better job vs. spending leisure time with friends or family, affording either an expensive holiday trip or a redecorated apartment, enrolling to a fitness class vs. watching TV in the evening, just to name a few. From an interpersonal point of view, goal conflicts can be found within the structure of enterprises and organizations. Managers in business and industry, e.g., ought to keep a balance between financial gains, customers' demands, efficient work processes and both sustaining and developing employees' human resources [1]. Multiple goals may arise from the demands of multiple lobbies. They can entail both interpersonal goal conflicts between the lobbies' members as well as intrapersonal goal conflicts within an ambivalent manager's mind.

Yet, to pursue multiple and conflicting goals is more than a mere decision on priority, subordinate and dispensable goals. The manager in our example additionally needs to figure out how each of the goals can be achieved. Experience through exploration, analytical and practical skills are necessary to overcome barriers that make the desired state differ from the situation at hand – a prototypical instance of complex problem solving [2].

In the present paper, we investigate how cognitive representations and strategies in problem solving are affected by goal conflicts. Emphasis is put on the interaction between cognition, motivation, and the experience of distress. A complex dynamic control (CDC) task approach is reported and applied in two subsequent experiments.

MULTIPLE GOALS IN COMPLEX PROBLEM SOLVING

Speaking in terms of a general definition, complex problems represent multifaceted, dynamic situations that involve a large number of interconnected elements. The exact, underlying relationships between a problem's components are unknown to the person struggling with the problem. Besides this, the complex problem can be denoted as polytelic (i.e., implying multiple goals): Problem-solvers are confronted with a number of different goal facets to be weighted and coordinated [2].

RELATIONSHIPS AMONG MULTIPLE GOALS

As any given complex problem constitutes a system of connected elements, goals within the problem structure usually do not stand apart, but are linked according to one of three relational types: *goal independence*, *goal compatibility*, or *goal interference* [3]. For dyads of two goals each, the relational types can be defined as follows: In case of *goal independence*, in spite of interrelated elements in a problem space goals can be pursued and achieved separately from one another. Goal A has no effect, neither positive nor negative,

*Address correspondence to this author at the Psychologisches Institut, Universität Heidelberg, Hauptstraße 47-51, D-69117 Heidelberg, Germany; Tel: ++49 6221 54-7305, -7388 (Secr); Fax: ++49 6221 54-7273; E-Mail: Christine.Blech@psychologie.uni-heidelberg.de

on goal B and vice versa. *Goal compatibility*, sometimes termed goal facilitation or *goal synergy*, refers to contexts in which achieving goal A increases the probability of achieving goal B at the same time. *Goal interference* – finally and most interestingly in our study – occurs if two goals cannot be achieved simultaneously without considerable extra effort or cannot be achieved simultaneously at all. Successful actions towards goal A will decrease the probability of reaching goal B as well. *Goal interference* should occur if both goals require equivalent, but limited resources (e.g., time, cognitive capacities) and compete for them as found in multitasking paradigms [4]. Besides such indirect goal conflicts based on parallel demands, goals can be opposed when their consequences are mutually exclusive. In an extreme specification, goal A would be the precise negative mirror image of goal B (not-A), making combined success logically impossible. We will refer to these conflict situations as *goal antagonism* and provide examples in the method section below.

CURRENT STATE OF RESEARCH

In how far has empirical research taken into account the effects of multiple and conflicting goals? At first glance, research on goal conflicts appears to be abundant. Beginning with the work of Kurt Lewin [5] it has been widely recognized that goal conflicts are difficult to deal with. Many issues stemming from Lewin's tradition are settled in the primary field of *motivational psychology* with particular respect to long-term personal strivings and wellbeing [6, 7]. Emmons and colleagues [8, 9] report increased levels of conflict-related stress and reduced wellbeing, although under certain conditions stabilizing effects of multiple goals on wellbeing have been observed [10]. Studies from the field of action psychology and multitasking paradigms [4] explain reduced performance by limitations of human cognitive capacity.

Issues focusing on goal conflicts in *complex problem solving*, however, are comparably scarce. Firstly, a straightforward and well-supported general prediction is that the more goals are to be handled simultaneously the worse goal achievement will be. With respect to complex problem solving, an experiment by Funke [11] is in line with this view. Participants dealing with four parallel goals in a CDC simulation performed worse on goal achievement and acquisition of goal-related knowledge than control subjects dealing with only two goals in the same complex system. The effect was observed although no explicit goal antagonism was inherent to the problem structure.

Secondly, besides the mere number of goals their quality has required consideration. A CDC problem-solving experiment by Vollmeyer and Burns [12] provided evidence that participants instructed to merely explore a CDC system (unspecific goal) gained more system-related knowledge than participants instructed to reach specific goal values. As Vollmeyer and Burns [12, 13] argue, single, specific goals can promote the acquisition of isolated solution paths, but in order to gain broad, comprehensive knowledge goal specificity will be less helpful.

AIM OF THE CURRENT STUDY

In the discussion of problem solving under polytelic conditions, thus far, some authors have been implicitly assuming underlying goal conflicts [2], but lacked a closer look at how problem solvers actually perceive goal relations. The study at hand aims at a clear separation between multiple goals on the one hand and conflicting goals on the other hand. Using the taxonomy presented above, we will investigate effects of explicit goal antagonism in a formal complex problem-solving paradigm. Additionally, we will reconsider the impact of capacity limitations by varying the number of conflicting goals in a second study.

HOW GOAL CONFLICTS MIGHT AFFECT COMPLEX PROBLEM SOLVING: A FRAMEWORK

The main concern of our study is to combine the above named perspectives from motivational psychology and the perspective of complex problem solving. An initial move towards a cognitive-motivational framework of problem solving under polytelic situations is developed. Our pioneer framework includes five hypotheses to be tested (see Fig. **1**).

Hypothesis 1: In complex problem situations involving antagonistic goal relations, problem solvers report losses of current motivation.

We expect measures of current motivation to decrease in problem-solving situations of antagonistic structure since antagonism implies at least partial non-attainment of goals. Given that two goal states cannot be achieved at the same time, subjects should be prompted to settle for moderate success concerning both goals or they might accept failure for one goal combined with success for the complementary goal. Whereas in real life further strategies might be conceived (e.g., striving for one goal first and for the other goal next, trying to find common aspects to link both goals on a conceptual level), according to our understanding of goal antagonism, goal redefinitions are limited. Disappointment is therefore pre-assigned in either case, independent of individual goal management.

The feasible assumption that goal failure induces low motivation finds empirical support for both long-term strivings and relatively straightforward achievement tasks in experimental settings (e.g., [14-16]). Mediated by pre-installed (partial) failure, participants should suffer from losses in current motivation.

Hypothesis 2: In complex problem situations involving antagonistic goal relations, problem solvers report increases in experienced stress symptoms.

Similar to hypothesis 1, we assume that in addition to supposed motivational effects subjective wellbeing including physiological symptoms, too, will be impaired for situations of conflicting goals. We predict increased rumination about non-attainment, depressive mood, and perceived stress [17].

Hypothesis 3: In complex problem situations involving antagonistic goal relations, problem solvers adopt a deliberate, state-orientation-like approach towards the problem.

Rumination associated with depressive mood can be considered as a specific cognitive style. When struggling with non-attainable and non-attained goal standards, frustrated problem-solvers should be less prone to undertake immediate measurements of exploration or goal-directed problem solving. By the conflicting goal structure, action is more or

considered with respect to promoting the corresponding goal. Averaged effectiveness ratings provided the basis of effectiveness parameters implemented in the computer program.

Structure of the CDC Task

The variables from our list that can be manipulated by the participant are called the input or exogenous variables. The two-goal version of our scenario (Experiment 1) involves 18 such variables, the extended four-goal scenario (Experiment 2) involves 36 exogenous variables. Endogenous variables are the two goal variables contentment of passengers and productivity of employees in Experiment 1 and the four goal variables contentment of passengers (CP), productivity of employees (PE), quality of management, and public reputation of ship owner in Experiment 2. For illustration, we describe the conflict manipulation between two goals in detail. For a description of the four-goal version see the method section of Experiment 2.

Being a dynamic problem, the CDC task consists of a sequence of intervention steps. Problem solvers choose measures from the lists, i.e., they make interventions, which in turn are followed by a feedback of the system and then by the participant's next intervention. The system provides feedback as numerical scores of the endogenous variables, starting with the default value of 100 at the outset. The higher the score, the more successful the goal attainment.

Exogenous variables affect the endogenous scores as follows: Each input variable has been assigned a defined, numerical weight, i.e., its effectiveness. A highly effective measure such as "increase payment of wages" would yield a weight of 4 points, a moderately effective measure such as "renovate staff canteen" would yield a weight of 2 points, and a non-effective measure such as "apply recruitment tests" would yield a weight of 0 points. Among the nine exogenous variables associated with a goal, there are three variables from each category. For all exogenous variables chosen during an intervention step, the corresponding weight scores will be summed up. In order to prevent that subjects simply pick all exogenous variables, cost scores will be subtracted. Costs are implemented so that selecting the full range of interventions will neither yield an increase nor a decrease in the goal scores. Instead, to raise goal scores, participants are challenged to experiment and search for effective single or combined measures from the intervention list. Also, if a particular – and particularly effective – combination of inputs is selected, a predefined bonus score will be added. Picking the three highly effective measures "increase payment of wages", "send machine operators on advanced training courses", and "award bonuses for special achievements" on the side of PE and none but these, e.g., will be rewarded by 12 extra scores.

Weight scores, bonuses and costs will be totaled to form an intervention score which directly relates to an endogenous variable. If the current score of CP has been 100 and 12 points have been gained due to manipulations listed under CP, the next step's score of CP will be 100 + 12 = 112. Similarly, if the current state of PE has been 100 and 4 points have been gained due to manipulations listed under PE, the next step's score of PE will be 100 + 4 = 100. So far, this example illustrates an independent goal relation. To turn it into a conflict relation, points gained on the part of CP will be subtracted from the total score of PE and vice versa, e.g., as to CP 100 + 12 – 4 = 108 and as to PE 100 + 4 – 12 = 92. This implies that for antagonistic goals in the approach at hand, in fact, the sum score of both goals will maintain a constant level. Gains regarding the goal CP can only be realized at the expense of equally large losses concerning the goal PE.

Besides this manipulation of an immanent goal conflict (*goal antagonism*), for the purpose of between-subjects comparisons in the experimental design we established a version of the above explained *goal independence* and a *goal synergy* version. Goal synergy implies the same degree of formal complexity as goal antagonisms, but instead of subtracting, points gained on either side are added to both goals. Following the example this would lead to a score of 100 +12 + 4 = 116 for CP and an equal score of 100 + 4 + 12 = 112 for PE.

EXPERIMENT 1

Method

Participants. 69 participants (15 male, 54 female) were recruited at the Department of Psychology at the University of Heidelberg, Germany. Most subjects were undergraduate students in psychology, ranging in age from 18 to 45 (M = 22.35, SD = 5.14). To compensate for participation, students were given course credit. For two participants, electronic recording of problem-solving activities partly failed. To ensure balanced three-level ANOVA analyses, from a random observation of the third experimental condition we removed corresponding data, leading to sixty-six complete data records (22 per goal condition). Gender ratios were equal for the three experimental conditions.

Design. *Goal relation* was manipulated between subjects on three levels: goal antagonism, goal independence, and goal synergy. Participants worked on the goal scenario for two identical and subsequent rounds; "*time*" was hence introduced as a two-level within-subject-factor in a 2 × 3 ANOVA design.

Procedure. After a brief outline of the experimental procedure, by signature subjects gave their informed written consent to participate. They were reminded that taking part was voluntary and that they might abandon the experiment if they wished to. Instruction phase furthermore comprised a questionnaire on self-regulatory habits (HAKEMP), an introduction on how to handle the computer simulation, and self-report questionnaires on pre-experimental stress and current motivation. Subjects passed through two phases of complex problem solving, each consisting of a ten-step-interaction with the CDC task and afterwards questionnaires on system-related knowledge, self-reported strategic approaches, stress, and current motivation. Goal relation was randomized between subjects, i.e., one third of the sample worked on an antagonistic goal scenario, one third on an independent goal scenario, another third on a synergistic goal scenario. The goal relation assigned to a participant remained the same throughout the two phases. Final measures on socio-demographical variables and school achievement were retrieved from questionnaires after Phase 3. Subjects were debriefed concerning the purpose of the study and received course credit and chocolate in return for their services.

Materials and measures. The "Hanssen Shipping Company" simulation was created with the aid of the programming tool AgentSheets, version 1.6 X [24]. Subject data were written automatically into MS excel files while running the system. A screenshot of the two-goal-scenario is provided by Fig. (**2**). Labels are translated into English. The original version employed in our experiment contained German labels. All information necessary to work on the problem is compiled in one window. The upper part displays achievement status for both goal demands by score numbers, horizontal bars represent the score graphically, and arrows indicate either an upward, downward, or a constant development of goal scores. From the lists below, users point and click boxes to select or deselect relevant measurements by visible check marks. Once they have finished they submit their inputs by operating the "finished" button, then switching to a new simulation month, i.e., a new intervention step. Check marks from the previous month are then removed. Participants run through a sequence of ten such in-ter-de-pen-dent steps. From the instruction participants were encouraged to start their exploration on the base of pre-existing knowledge and plausibility. Yet they were clearly pointed to the fact that semantic relations in the scenario might dissent from their individual expectancies and that it might be indicated to modify one's problem-solving behavior accordingly.

To assess task-related *current motivation* we employed the German version of the questionnaire of current motivation (QCM) developed by Rheinberg, Vollmeyer, and Burns [25]. The QCM form contains 18 statements to appraise on a 7-point Likert scale. Sample items from the QCM are, e.g., "I would work on this task even in my free time" (interest), "I think I am up to the difficulty of the task" (probability of success), or "I feel under pressure to do this task well" (anxiety).

Experienced stress symptoms were retrieved by 12 items of a self-report 7-point Likert scale that was constructed from dimensions of perceived stress symptoms according to Kohli [26], e.g., strain, resignation, impatience, anger, restlessness.

Another 10-item self-report questionnaire (5-point Likert scale) asked about styles of subjects' intervening manipulations. Construction of this measure followed a scale of habitual decision-making styles by Scott and Bruce [27]. Ratings concerning perceived rationality ("I reflected each step carefully"), avoiding decisions ("Often I hesitated because I could not make a decision"), intuition ("Often I decided by intuition"), dependency from others ("I would have liked to ask somebody for advice"), and spontaneousness ("Most of the time I decided spontaneously") were combined to describe *cognitive approaches* towards the problem. For the same purpose we recorded and analyzed solution times.

Systematics of manipulation strategies was inferred from the number and ratio of chosen interventions. Low mean intervention frequencies were labeled systematic. An index of balanced vs. imbalanced intervention approaches was calculated as follows: number of interventions corresponding to goal A minus number of interventions corresponding to goal

Fig. (2). User interface of the "Hanssen Shipping Company" CDC task. The two goals (**a**) contentment of passengers (left) and (**b**) productivity of employees (right) are shown together with the lists of possible measurements.

B for intervention step *t*. The mean absolute value of these differences averaged above ten steps yielded the balance index. Low scores indicate a balance-focused strategy.

As a test of *acquired system-related knowledge* subjects completed an assessment questionnaire about the intervention list. They rated each intervention according to how it affects both the first and the second goal. Ratings employ a 5-point scale from supposed advantageous effects to supposed disadvantageous effects. An index of acquisition of system-related knowledge was calculated by comparing subjects' responses to the preset impact categories and by accounting for antagonistic or synergistic goal relations. Perfect ratings were scored 1, ratings from suboptimal, but adjacent categories were scored zero, ratings differing two or more categories from the preset value were punished by minus one score.

For purposes of experimental control and additional testing we recorded subjects' age, sex, profession or field of study. As an approximate indicator of cognitive ability final school exam grades (overall grade and math grade in particular) were surveyed. Motivational personality habits of action orientation or state orientation were raised by means of Kuhl's questionnaire on action-control HAKEMP [28]. Analyses concerning these variables yet yielded no significant effects and will not be reported for the sake of brevity.

Results

Motivation and Stress. After factor analytical exploration of self-report data (PCA, varimax rotation), from QCM items two 9-item-subscales were generated that corresponded to the combined QCM subscales "anxiety – probability of success" (AP) and "interest – challenge" (IC) from the original QCM [25]. Concerning pre-experimental motivation, participants of the three experimental conditions showed comparable levels of AP and IC, AP: $F(2, 68) < 1$, *ns*, IC: $F(2, 68) < 1$, *ns*. For AP measured after Phase 1 and 2, there was a significant main effect for goal relation, $F(2, 66) = 6.56$, $p < .01$, $f = 0.45$, indicating lower expectancy of success for participants of the antagonistic goal condition as compared to the two control groups ($p < .01$). However, no such effect occurred for IC, $F(2, 66) < 1$, *ns*.

The stress scale was reduced to a 10-item one-dimensional scale with Cronbach's alpha internal consistencies between alpha = .83 (pre-experimental) and alpha = .86 (after Phase 1). As with motivation, no significant effects prior to simulation experience were found, $F(2, 67) < 1$, *ns*. In Phase 1 and 2, however, a significant main effect occurred, $F(2, 65) = 4.84$, $p < .05$, $f = 0.39$. Post hoc contrasts revealed that perceived stress was significantly higher in the antagonistic goal condition ($p < .01$).

Overall, participants rated their probability of success relatively high. Mean ratings ranged from $M = 5.52$ ($SD = .13$; pre-experimental) to $M = 5.73$ ($SD = .11$; Phase 2) on a 7-point scale with an upward tendency over time, Pillai's Trace: $F(2, 65) = 5.70$, $p < .01$, $f = 0.42$. Stress levels in the experimental testing situation were constantly low over experimental conditions, with mean scores between $M = 2.39$ ($SD = .81$; Phase 2) and $M = 2.55$ ($SD = .86$; pre-experimental) on a 7-point scale, Pillai's Trace: $F(2, 64) = 1.32$, $p = .28$.

Cognitive style. Self-reports from the questionnaire of cognitive approaches in problem solving were analyzed according to two sub-dimensions gained from factor analysis (PCA, varimax rotation): systematic vs. heuristic style (6 items) and dependent-hesitant vs. assertive style (4 items). Typical items to characterize the systematic style were "I reflected on each step carefully" (systematic style) or "Often I decided by intuition" (heuristic style). The dependent-hesitant comprises items such as "Often I hesitated because I could not make a decision" (hesitant style) or "I would have liked to ask somebody for advice" (dependent style). The total variance explained by the two-factor solution was 46.83 % for Phase 1 and 58.70 % for Phase 2. For both subscales measures of internal consistency were satisfactory. Means of reported systematic styles did not vary significantly among groups, $F(2, 66) < 1$, *ns*. However, for the dependency scale effects of goal relation became highly significant, $F(2, 66) = 7.49$, $p < .01$, $f = 0.48$. This was due to higher ratings among participants of the goal conflict condition ($p < .01$). Reported dependency and hesitation within all groups markedly declined over time, i.e., problem-solvers became more assertive with growing experience, $F(1, 66) = 10.90$, $p < .01$, $f = 0.41$.

As behavioral measurements of hesitation we investigated mean solution times. These, too, showed a decline over time, reflecting effects of experience and habituation, $F(1, 66) = 111.91$, $p < .01$, $f = 1.30$. Yet we did not detect any differences attributable to goal condition, $F(66, 2) = 1.01$, $p = .37$. On a descriptive level, subjects dealing with the synergistic scenario spend the least time on the problem ($M = 29.27$, $SD = 2.80$) while on average subjects of the antagonistic ($M = 34.11$, $SD = 2.80$) and the independent goal group ($M = 34.17$, $SD = 2.80$) required virtually the same length of time.

Not quite consistently, there were positive relations between solution time and self-reported dependency. The higher perceived hesitation, the longer the time spent on the corresponding round of problem solving. Correlations were of moderate, but robust size, with coefficients of $r = .46$ for Phase 1 und $r = .34$ for Phase 2.

Problem-solving strategies. According to our hypothesis, for the antagonistic goal relation scenario, overall, we had assumed a reduction of selected interventions. This general prediction was not confirmed (Phase 1: $\chi(2) = 2.35$, $p = .31$, Phase 2: $\chi(2) = 1.08$, $p = .58$). In fact, subjects of the antagonistic goal condition performed more interventions in Phase 1, but fewer interventions in Phase 2 than did control subjects (see Fig. **3**). Control participants, on average, kept a constant level of system manipulations. This observation was tested statistically by comparing the pairwise differences of intervention scores from Phase 1 minus Phase 2. A highly significant Kruskal-Wallis test indicated that the differences were considerably higher under goal antagonism ($\chi(2) = 17.66$, $p < .01$). Hence, an interaction between time as a within-subject-factor and goal relation as a between-subject factor was identified.

The pattern of starting with strong manipulation in Phase 1 and weak manipulation in Phase 2 was observed not only with regard to between-subject effects, but also in an exploratory within-subject analysis. We divided subjects in two categories: those whose mean intervention score decreased

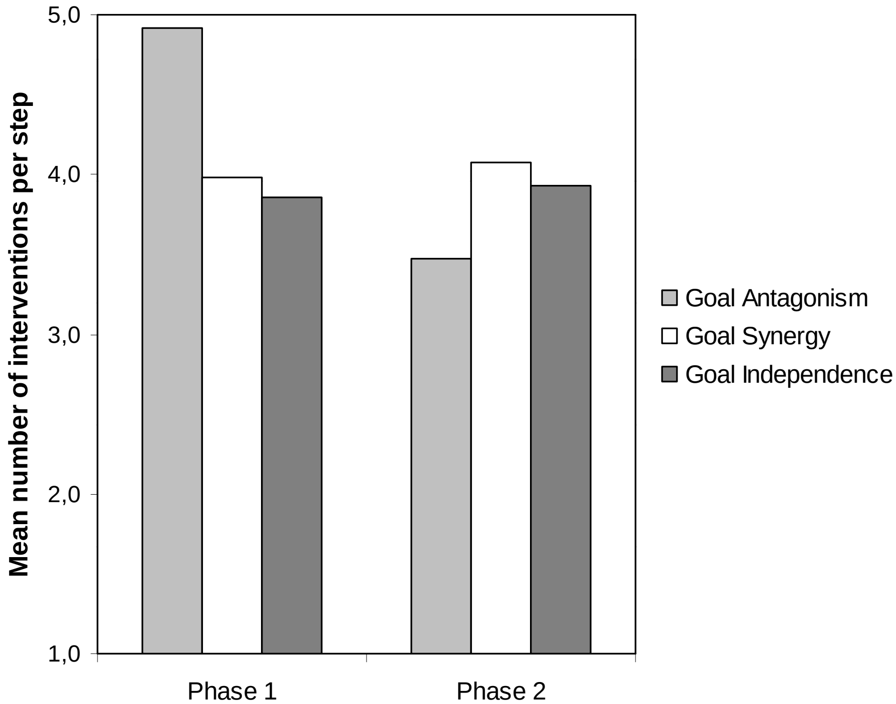

Fig. (3). Mean intervention frequencies as indicators of strategic approaches in problem solving in Experiment 1 (N = 69). The maximum number of selectable interventions was 18.

from round 1 to round 2 and those whose mean intervention score either increased or remained equal. Nearly all of the antagonistic goal participants were found to belong to the first category. In contrast, among independent and synergistic goal participants classification ratios appeared to be balanced, $\chi(2) = 15.56, p < .01$.

With respect to the second indicator of problem-solving strategies, intervention balance, our hypothesis predicted a more balanced manipulation behavior in case of antagonistic goals. We assumed that problem-solvers would equally mind the two goals and undertake about equal numbers of intervention on each side. However, results showed the reverse: Imbalance was significantly higher in the group of antagonistic scenario treatment ($p < .05, f = 0.38$). Closer analysis revealed that effects of raised imbalance only occurred in Phase 1, $F(2, 66) = 7.47, p < .01, f = 0.48$, but not in Phase 2, $F(2, 66) < 1$, *ns*. Hence, subjects confronted with antagonism started by using a rather imbalanced approach and tended to keep more balance later. Control participants on the contrary began their exploration balanced and prioritized goal handling later.

Taken the results together, no increased systematics according to the conventional view appeared. Yet the two indicators of strategy employment convey an adaptive pattern of self-regulatory processes in dealing with conflict problems. “Overreaction”, i.e., overregulation and intensified measures may be the initial response to cope with a difficult and frustrating antagonistic problem. In our first experiment reduced intervention was identified as late as in Phase 2, i.e., after some experience and possibly after a change in strategic approach.

Acquisition of system-related knowledge. Fig. (**4**) displays the indices of mean knowledge acquisition over Phase 1 and 2 related to experimental conditions. A highly significant main effect for goal relation appeared, $F(2, 66) = 16.34$, $p < .01, f = 0.70$. This was assignable to the immense amount of knowledge gained under independent goal conditions ($p < .01$). Comparing the two scenarios of equal connectedness, i.e., the antagonistic goal condition versus the synergistic condition, contrary to our expectation there were no meaningful differences ($p > .50$). The within subject-factor time proved significant and thus hinted at effects of learning and experience on understanding the unknown effects of interventions on goal states, $F(1, 66) = 5.77, p < .05$.

Discussion

Based on a cognitive-motivational framework we stated a number of characteristic effects occurring when complex problem-solving situations involve conflicting goals. Firstly, we argued that problem solvers’ current motivation would suffer from conflict experience as well as perceived stress levels would increase. The results support these assumptions although, considered from an absolute level, subjects still seemed confident and relaxed in spite of the preset goal conflicts. The finding is much in line with the well-documented everyday phenomenon that failing to reach goals or perceiving stagnation in planned transactions leads to frustration and stress [17, 29].

Yet the more difficult, potentially frustrating tasks are not necessarily the more boring ones according to participants’ ratings. No systematic interrelation between goal type and the combined scale of interest and challenge was found. General and more obvious features of appearance and usability might have influenced interest in the computer system than did the structural differences between experimental conditions. Furthermore, personality factors may have a

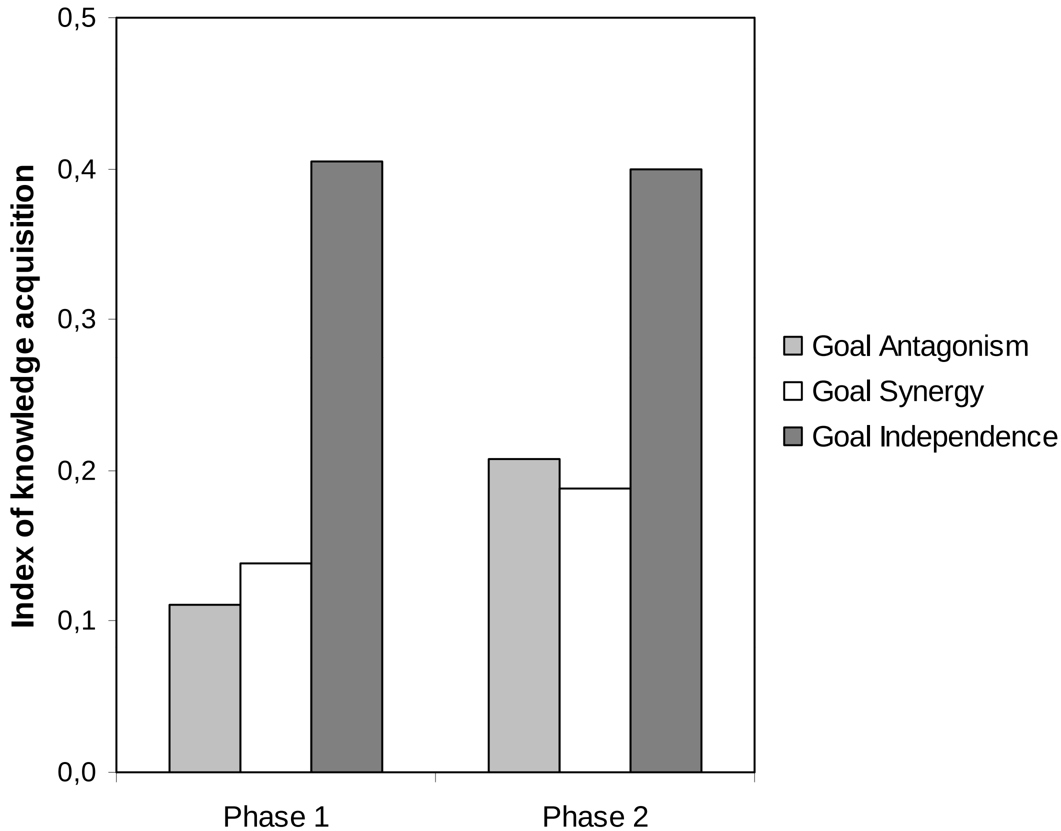

Fig. (4). Reproduction of participants' acquired system-related knowledge in Experiment 1 (*N* = 69).

great impact on this matter. From the perspective of personality, interest should depend on both a problem-solver's ability as well as on habitual preferences for difficult or simple ventures as related to achievement motivation [30]. In this case, however, indirect indicators of ability (school grades) turned out to be non-predictive.

Another expected characteristic of problem solving under antagonistic goal conditions was a passive, state-orientation like approach in handling the simulation scenario. This hypothesis turned out to fit with self-report data of hesitation and perceived feelings of dependency, but not with the objective amount of time spent on the task. As both indicators correlate positively, to some extent solution times tend to be affected by goal conflicts, too. But we presume that measurable solution time is no perfect mapping of hesitation and insecurity. During problem-solving subjects may slow down for a variety of reasons both related and unrelated to the problem at hand. For those who feel unassertive how to cope with the problem rumination and extended reflection time is simply one possible strategy among others. An alternative, e.g., would be to rush through the task, realizing that most effort in the conflict scenario will remain without substantial effect anyway. Thus, by analyzing mere solution times no insight is provided in whether problem-solving actions are constructive, reflective, and efficient or panic-like, non-reflective, and inefficient.

Cognitive indicators of problem solving in a narrower sense were observable strategies and knowledge acquisition. Results concerning the number and balance of selected interventions promote the idea that preset goal conflicts induce different types of strategies than do problems of multiple, independent goals. Against expectations, however, strategies appeared to be instable and showed dynamic variations over time. As a general trend averaged over participants and intervention episodes we observed a pattern of initial "actionism" and later intervention reduction. Paralleling this effect, subjects dealing with goal antagonism started with rather imbalanced manipulation patterns, i.e., they tended to promote the more deficient goal module and to ignore the other – until in the following step the formerly ignored module was deficient and had to be pushed. As the number of manipulations decreased over time, on the whole problem-solving strategies became more balanced and represent simultaneous pursuit of the two demanded goals. These specific changes did not appear when goals were independent or synergetically related.

Considering knowledge acquisition, successfully grasping the problem structure turned out to be a matter of the system's formal complexity or connectivity [11, 31, 32]. Subjects analyzed the system best and found out most correct information if parallel goals were unrelated. Obviously, testing the effects of single interventions is much easier if nine intervention measures contribute to influence a goal score than if the goal score is influenced by nine plus nine intervention measures. The hypothesis according to which goal antagonism drives problem-solvers to systematic, efficient acquisition of structural knowledge must be deferred because in spite of equal degrees of formal complexity, antagonistic goal subjects did not understand the system any better than their peers from the second control group, the synergistic goal condition.

To summarize, in Experiment 1 induced goal conflicts had temporary, but verifiable effects on motivational and cognitive facets in the process of complex problem solving. Namely, conflict experience impaired expectations of success, enhanced insecurity and stress. Problem-solving strategies can be characterized as a crossover from enhanced action to low, but possibly more thoughtful action. Knowledge acquisition does not benefit from antagonistic structures in a complex scenario. Instead, it is important to stress that goal conflicts are generally associated with intransparency and complexity, which complicates the process of gaining knowledge.

Experiment 2 was conducted to test whether the main findings could be generalized in a multiple goal setting involving more than two goals. The aim was to replicate motivational effects of goal antagonism and to justify post hoc explanations concerning self-regulative strategies on an independent data basis.

EXPERIMENT 2

Method

Participants. We tested 42 subjects (15 male, 27 female) who had not taken part in the first study and hence had no prior experience with the shipping scenario. In the sample, students of different fields of study were included (psychology, natural sciences, humanities, law, economics, and social sciences). 17 students (40%) were enrolled in psychology. The mean age was 25.46 (SD = .73) with a range from 17 to 40. Participants were free to choose between course credit and a payment of 5€. Gender ratios were equal for the two experimental conditions.

Design. Only two levels of goal relation were tested in a between-subject design: goal antagonism vs. goal independence. Measures from two identical rounds of problem solving led to time as a within-subject factor in a 2 × 2 ANOVA design.

Procedure. The course of experimental procedure was virtually the same as in Experiment 1: introductory phase, two rounds of scenario treatment followed by final recordings and debriefing.

Materials and measures. The main novelty of Experiment 2 concerned the construction of the CDC task. Antagonistic goal relations were established between the four, pre-tested goal demands. Antagonism followed a circular structure, i.e., in the conflict condition intervention scores of the goal contentment of passengers were subtracted from the quality of management scores, quality of management negatively affected the public reputation of the ship owner, ship owner's reputation negatively affected the productivity of employees and this, in turn, exerted antagonism on the contentment of passengers. In the extended version of "Hanssen Shipping Company" the four goal states and related measure lists were presented simultaneously on a single screen. As in Experiment 1, each round comprised ten intervention steps.

Measures of current motivation, experienced stress symptoms, cognitive solution approaches, and acquired system-related knowledge were adopted from Experiment 1. Regarding intervention balance, instead of the difference algorithm, we computed the variation of intervention frequencies per goal over the four goals of the same intervention step. These were averaged above the ten steps per round. High average variation scores are interpretable in terms of an imbalanced procedure whereas low variation reflects more balanced approaches.

Results

Motivation and stress. The two-factor FAM measures AP and IC as well as the 10-item perceived stress scale from Experiment 1 were confirmed and adopted. Pre-experimental differences were found neither for the AP and IC motivational subscales nor for the stress scale, AP: $t(40) = .07$, *ns*, IC: $t(40) = 1.33$, $p = .20$, stress: $t(40) = 1.70$, $p = .10$. Contrary to our expectations and first findings, repeated measures over Phase 1 and 2 yielded no significant effects of motivation although AP and IC tended to be lower in the antagonistic goal condition, AP: $F(1, 40) = 2.81$, $p = .10$, IC: $F(1, 40) = 1.75$, $p = .19$. Comparisons of stress means over Phase 1 and 2 reached marginal significance in the predicted direction, $F(1, 40) = 3.99$, $p = .05$. The effect was more prominent for Phase 1, i.e., after subjects' initial confrontation with the conflict scenario, than after Phase 2.

In line with the previous results, mean ratings of AP above three measuring times ranged from $M = 5.62$ ($SD = .18$) to $M = 5.68$ ($SD = .16$). Stress ratings ranged from $M = 2.75$ ($SD = .19$) to $M = 2.93$ ($SD = .21$). In brief, participants were relatively confident and relaxed in mastering the simulation problem with a tendency of impairment when goal conflicts existed.

Cognitive style. The two studied self-report dimensions, systematicity and dependency – hesitation, were the same as in the first experiment. As only dependency proved sufficiently stable in the check of internal consistency, the systematicity scale was omitted. For self-reported dependency, a significant main effect of goal relation was found, $F(1, 40) = 6.43$, $p < .05$, $f = 0.40$. As predicted, subjects of the antagonistic goal condition rated perceived hesitation higher. Once again, no corresponding effect of solution time occurred, $F(1, 40) < 1$, *ns*. Hesitation tended to decrease over time although not significantly, $F(1, 40) = 2.37$, $p = .13$. Concerning solution times the effect of customization was highly prominent, $F(1, 40) = 121.09$, $p < .01$, $f = 1.74$.

Problem-solving strategies. In line with our original hypothesis, but partly differing from the first study, in Experiment 2 we identified significantly lower intervention frequencies in the antagonistic goal condition than in the independent goal condition. The findings refer to both Phase 1 and Phase 2 (Phase 1: $U = 110.00$, $p < .01$, Phase 2: $U = 85.00$, $p < .01$). Subjects dealing with the antagonistic problem started on a low intervention level and reduced manipulation frequencies even further. Subjects of the independent goal condition showed but a slight decline in manipulation frequencies on a higher starting level (see Fig. **5**). Corroborating prior interaction results, the decline over time was significantly more pronounced when goals interfered than when they were independent ($U = 136.50$, $p < .05$).

The index of imbalanced problem-solving behavior did not turn out to differ significantly between the two experimental conditions (Phase 1: $U = 165.00$, $p = .34$, Phase 2:

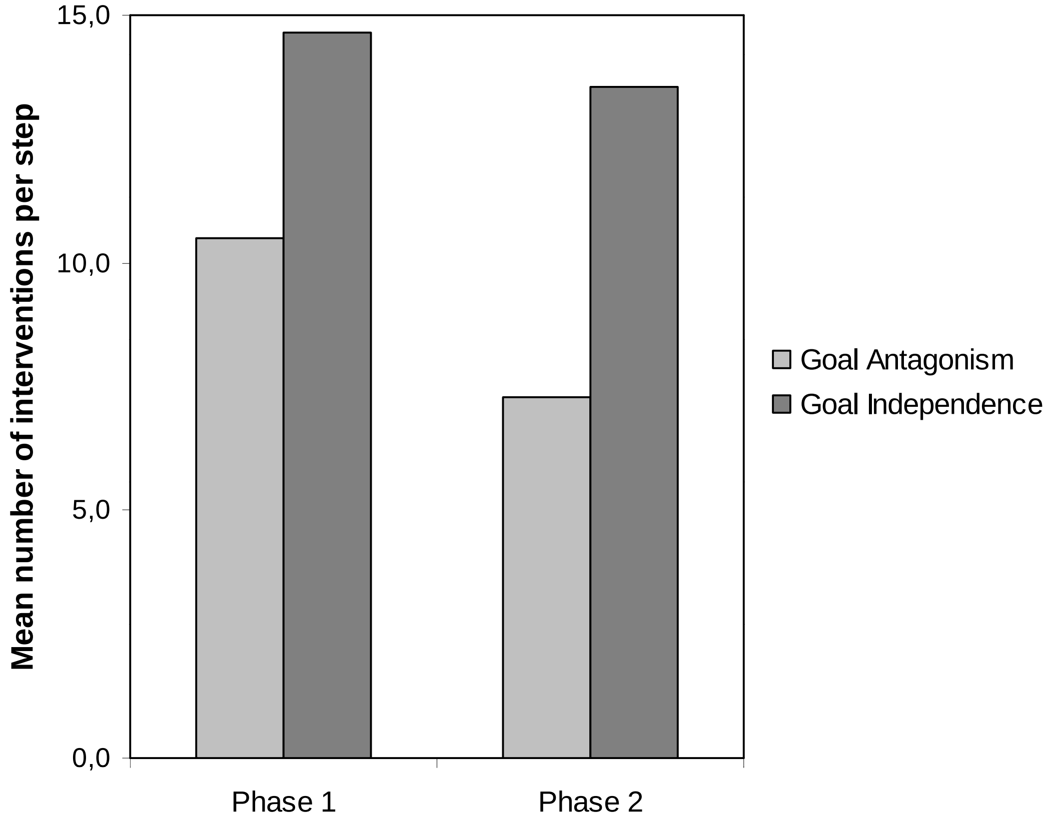

Fig. (5). Mean intervention frequencies as indicators of strategic approaches in problem solving in Experiment 2 (N = 42). The maximum number of selectable interventions was 36.

U = 167.00, p = .37). As found in Experiment 1, the difference between the Phase 1 variation score and the Phase 2 variation score was higher for antagonistic goal condition subjects, i.e., only these participants inclined towards a more balanced approach. Yet statistics did not firm up descriptive observations (U = 184.00, p > .50).

Acquisition of system-related knowledge. Subjects of the more complex experimental conflict condition performed worse on the knowledge test than did their peers of the independent goal condition, $F(1, 40) = 18.67, p < .01, f = 0.68$.

Combining and Comparing the Results from Experiment 1 and Experiment 2

An additional issue approached the question of how the number of preset goals in a complex problem-solving paradigm affects motivation and cognition. Analyses are based on a merged sample of subjects from Experiment 1 and 2. Only participants of the antagonistic and the independent goal condition were included, leading to a total sample size of N = 88. The three two-level factors goal number (two vs. four), goal relation (antagonistic vs. independent) and time make up a nearly balanced, quasi-experimental 2 × 2 × 2 ANOVA design with cell sizes of either N = 21 or N = 23 and repeated measures.

Dependent variables to be examined were the following: the motivational scales anxiety – probability of success and interest – challenge, stress, solution time and reported dependency. For none of these variables interactions between goal number and goal relation were found. Main effects of goal relation conform to those from single-experiment analyses. The factor goal number reached significance for the IC scale, $F(1, 84) = 7.89, p < .01, f = 0.31$, and for solution time, $F(1, 84) = 65.98, p < .01, f = 0.89$. Subjects working on the extended four-goal scenario rated the task more interesting and spent almost twice as much time on it. On average, participants in Experiment 1 took M = 34.14 s (SD = 2.39) per intervention step, whereas participants in Experiment 2 took M = 62.25 s (SD = 2.50). No differences occurred with regard to self-assessments of probability of success, $F(1, 84) < 1$, *ns*, stress symptoms, $F(1, 84) < 1$, *ns*, and hesitation, $F(1, 84) < 1$, *ns*.

Discussion

Experiment 2 reinvestigated the cognitive-motivational model of goal antagonism in complex problem-solving in the context of four instead of two conflicting goals. Impairing effects of goal interference on motivation and wellbeing were not as distinct and robust as in the first study. They tended to last but for the first of two rounds in working on the computer simulation. Possibly, as the four-goal scenario contained twice as many intervention measures than the two-goal scenario, this task was rather complicated even in case of goal independence, and discriminatory power due to the goal relation factor was reduced. Some participants under the goal conflict condition noted they knew declining goal scores were “not their own fault” and remained unimpressed by the computer’s negative feedback on control performance. A closer look at processes of attribution might be helpful for future investigations.

Concerning strategy employment the results convey a partly ambivalent picture. Based on the enlarged four-goal-scenario they confirm our new, adopted assumption that conflict experience is followed by reduced intervention engagement. Yet initial overregulation, i.e., enhanced manipulation of the system was not observed. One explanation might be that with the extended list of intervention measures, in either treatment condition it was evident right from the beginning that ten intervention steps would be insufficient to test each single measure step by step. So both antagonistic and independent goal problem-solvers might have started with a rather broad, heuristic selection of possibly efficient manipulations.

The relation between goal interdependency and gained structural knowledge about the system was clearly as predicted: The independent goal scenario seems to facilitate analytical reasoning about interventions' effectiveness. Subjects gave more correct ratings of interventions' effectiveness. The hypothesis that formal complexity due to intransparency and connectivity is a major determinant on performance in complex problem solving finds further empirical support.

Comparative analyses of Experiment 1 and 2 show that when confronted with four instead of two goal demands problem-solvers' motivation, wellbeing, and cognitive-behavioral performance is not affected in a negative way. On the contrary, interest is raised. Problem-solvers seemed to find it challenging handling four goals simultaneously, and they accepted the challenge as their long solution times suggest. Generally speaking of a manageable number of parallel goals, a major motivational loss does not result from a struggle for limited cognitive resources, but from difficulties in arranging goals with mutually exclusive consequences. As long as four goals in a computer simulation are concerned, limitations of cognitive capacity cannot offer sufficient explanation for the reported findings. To investigate how many parallel goals will entail capacity overload and concomitant factors, however, can broaden the perspective of research on goal conflicts in the future.

GENERAL DISCUSSION AND CONCLUSIONS

The aim of the reported study was to examine motivational and cognitive effects of conflicting goals or strivings. Goal conflicts are well known, universalized phenomena experienced in both group interactions and intra-individual struggling. Our work focused on the intra-individual perspective with particular regard to new, non-routine situations in which an existing incongruity between goals must be detected and managed. Although empirical research has reliably shown motivational impairment of long-term conflict experience (e.g., [9]) the specific approach to problem solving is a new one. Thus far, in the domain of complex-problem solving systematic investigations on polytely have been scarce. As a tool of experimental manipulation and control of goal conflicts we applied a complex dynamic control task, an engaging, game-like computer simulation in which approaching one goal could be performed but at the expense of falling short of another goal.

The results of two studies (N = 111) support the notion that even in a standardized laboratory setting goal conflicts can be induced. These conflicts lessen motivation during the process of complex problem solving. Reduced confidence in success, impaired wellbeing and increased hesitation are measurable consequences. The findings fit well with the first three out of the five hypotheses we propose in our above framework.

Yet from our experiments there is no evidence that conflict-induced motivational losses strongly affect cognitive problem-solving performance in a linear predictable manner. On a descriptive level we can infer that people becoming gradually aware of a goal conflict react to this awareness in some way. They reveal changed patterns of exploration strategies. Namely, as a generalized trend they will increase action initially. With growing experience manipulations will decrease. Paralleling this effect, problem-solvers will be inclined to try a balanced pursuit of the incompatible goals. In the present studies manipulation patterns were only observed on the base of aggregated data, i.e., effects averaged over experimental treatment conditions and time steps. Extended individual process analyses including think aloud protocols and time-series designs might yield more precise patterns. These in turn would help to refine the strategy hypothesis in our framework as well as the hypothesis of knowledge acquisition.

Our experimental work did not confirm the idea that demotivated problem solvers who are struggling with induced goal conflicts can analyze and reproduce formal relationships within the structure of a complex scenario any better or worse than do relaxed, motivated participants of a control condition as long as the degree of formal complexity is identical. To reinvestigate this fifth hypothesis of the framework it might be necessary to extend subjects' exploration opportunities. In order to systematically test for effects of single manipulations the number of exploration trials should be increased possibly in combination with less intervention measures to be selected.

Hence, overall there is empirical evidence supporting the framework, but connections between motivational and cognitive effects of goal conflicts will need further inspection. Although the high impact of motivation and cognition or learning has frequently been stressed in research [21, 33] two general concerns can make it difficult to establish strong relations in an experimental paradigm. Firstly, conflict experience does not refer to personal, intrinsic goals. Brunstein and Maier [6] argue that prescribed "told-to-do" goals, too, are prone to arouse conflict, still an experimental induction cannot claim that goal conflicts are deeply grounded in problem-solvers hearts and minds. Secondly, in some cases, simulated conflicts might simply appear interesting and appealing to problem solvers, but not threatening, similar to entertaining polytelic computer games. Our approach was clearly an experimental one, emphasizing differences between treatment groups instead of personality effects. By realizing equal gender ratios among goal relation conditions, the predominance of female participants in our sample still allowed for internal validity. Gender-related styles in goal management, however, might be an issue to be studied in larger samples with equal gender distributions.

In developing the framework of multiple goal effects further we also suggest to take into account the number of conflicting goals. Our exploratory investigation reveals that conflicts between two goals are no less demotivating than conflicts among four goals. More systematic variation over an extended range of goal numbers would help to elucidate to what extent limitations of cognitive processing capacity play a role in dealing with multiple and conflicting goals. The more goals to manage the more crucial interference due to overstress will presumably become. Individual strategies such as prioritizing goals and dismissing others may unfold influence when more than two goals are presented.

Another future concern refers to multiple goals arising from the demands of multiple lobbies (e.g., economy vs. ecology in a political setting). As mentioned in our introductory example of an ambivalent manager, intrapersonal goal conflicts only focus a narrow aspect of multiple strivings. A broader perspective should deal with interpersonal goal conflicts and the question whether and how the communication of multiple demands between people relates to goal conflicts in a single person's mind. Selecting problem-solving participants on the base of different preferences (e.g., determined economists vs. resolute ecologists) might convey induced goal conflicts into real life goal conflicts. Nevertheless, the CDC conflict paradigm might provide a tool to analyze such even more complex interactions in goal pursuit for standardized, non-routine situations, if presented as a team task in an interactive computer simulation.

REFERENCES

[1] Kaplan RS, Norton DP. The balanced scorecard – measures that drive performance. Harvard Business Rev 1992; 70: 71-9.

[2] Dörner D, Kreuzig HW, Reither F, Stäudel T. Lohhausen. Lohhausen. Problem solving in uncertain and complex problems. Bern: Huber 1983.

[3] Graham JA, Argyle M, Furnham A. The goal structure of situations. Eur J Soc Psychol 1980; 10: 345-66.

[4] Schubert T. The analysis of dual-task interference effects. Z Exp Psychol 1996; 43: 625-56.

[5] Lewin K. The psychological situation in reward and punishment. Leipzig: Hirzel 1931.

[6] Brunstein JC, Maier GW. Personal goals: a state-of-the-art review. Psychol Rundsch 1996; 47: 146-60.

[7] Riediger M, Freund AM. Interference and facilitation among personal goals: differential associations with subjective well-being and persistent goal pursuit. Pers Soc Psychol B 2004; 30: 1511-23.

[8] Emmons RA. Abstract versus concrete goals: personal striving level, physical illness, and psychological well-being. J Pers Soc Psychol 1992; 62: 292-300.

[9] Emmons RA, King LA. Conflict among personal strivings: immediate and long-term implications for psychological and physical well-being. J Pers Soc Psychol 1988; 54: 1040-8.

[10] Kehr HM. Goal conflicts, attainment of new goals, and well-being among managers. J Occup Health Psychol 2003; 8: 195-208.

[11] Funke J. Dealing with dynamic systems: research strategy, diagnostic approach and experimental results. Ger J Psychol 1992; 16: 24-43.

[12] Vollmeyer R, Burns BD. Hypothesis instruction and goal specificity: factors influencing the learning and control of complex systems. Z Exp Psychol 1996; 43: 657-83.

[13] Vollmeyer R, Burns BD, Holyoak KJ. The impact of goal specificity on strategy use and the acquisition of problem structure. Cognitive Sci 1996; 20: 75-100.

[14] Morgan PL, Fuchs D, Compton DL, Cordray DS, Fuchs LS. Does early reading failure decrease children's reading motivation? J Learn Disabil 2008; 41: 387-404.

[15] Moulton RW. Effects of success and failure on level of aspiration as related to achievement motives. J Pers Soc Psychol 1965; 1: 399-406.

[16] Weiner B. The effects of unsatisfied achievement motivation on persistence and subsequent performance. J Pers 1965; 33: 428-42.

[17] Rasmussen HN, Wrosch C, Scheier MF, Carver CS. Self-regulation processes and health: the importance of optimism and goal adjustment. J Pers 2006; 74: 1721-47.

[18] Fiedler K, Nickel S, Asbeck J, Pagel U. Mood and the generation effect. Cognition Emotion 2003; 17: 585-608.

[19] Klahr D, Dunbar K. Dual space search during scientific reasoning. Cognitive Sci 1988; 12: 1-55.

[20] Klahr D. Exploring science: the cognition and development of discovery processes. Cambridge, MA: MIT Press 2000.

[21] Rheinberg F, Vollmeyer R, Rollett W. Motivation and self-regulated learning: a type analysis with process variables. Psychologia 2002; 45: 237-49.

[22] Schauble L. The development of scientific reasoning in knowledge-rich contexts. Dev Psychol 1996; 32: 102-19.

[23] Tschirgi JE. Sensible reasoning: a hypothesis about hypotheses. Child Dev 1980; 51: 1-10.

[24] Repenning A. AgentSheets (1.6 X). Boulder, CO: AgentSheets Inc. 2003.

[25] Rheinberg F, Vollmeyer R, Burns BD. FAM: a questionnaire to assess current motivation in learning situations. Diagnostica 2001; 47: 57-66.

[26] Kohli GS. Stress and anger reactions in psychosomatic and healthy persons. Ph.D. diss., Dept of Psychology, Ludwig-Maximilians-Universität München 1988.

[27] Scott SG, Bruce RA. Decision-making style: the development and assessment of a new measure. Educ Psychol Meas 1995; 55: 818-31.

[28] Kuhl J. A theory of self-regulation: Action versus state orientation, self-discrimination, and some applications. Appl Psychol-Int Rev 1992; 41: 97-129.

[29] Brunstein JC. Personal goals and subjective well-being: A longitudinal study. J Pers Soc Psychol 1993; 65: 1061-70.

[30] Niemivirta M. Motivation and performance in context: The influence of goal orientations and instructional setting on situational appraisals and task performance. Psychologia 2002; 45: 250-70.

[31] Birney DP, Halford GS. Cognitive complexity of suppositional reasoning: An application of the relational complexity metric to the knight-knave task. Think Reason 2002; 8: 109-34.

[32] Halford GS, Wilson WH, Phillips S. Processing capacity defined by relational complexity: implications for comparative, developmental, and cognitive psychology. Behav Brain Sci 1998; 21: 803-65.

[33] Vollmeyer R, Rheinberg F. Motivational influences on the acquisition and application of knowledge in a computer-simulated system. Z Padagog Psychol 1998; 12: 11-23.

Received: July 22, 2009 Revised: September 05, 2009 Accepted: December 21, 2009