

# Discovery Learning in Sports Decisions Implicit or Explicit Processes?

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## Introduction

Discovery learning is believed to be an effective method for acquisition of motor, anticipation, or cognitive skills. The mechanisms leading to improvements are not well understood in the context of sports. Some researchers suggests that discovery learning is based on implicit learning processes (e.g., Williams, et al., 2002), whereas, others argue that explicit processes predominate if hypothesis testing is present (e.g., Liao & Masters, 2001).

## Main Text

An experiment was designed to explore the effects of discovery learning compared to pure implicit and explicit learning of “if-then” relationships between stimuli and tactical decisions in basketball. If the underlying mechanisms of discovery learning are implicitly biased then both the behavior and the accumulated knowledge base should mirror the implicit learning group. If the underlying mechanisms of discovery learning are explicitly biased then the behavior and knowledge base should mirror the explicit learning group. If implicit and explicit processes are both present in discovery learning and the mechanisms interact positively within the discovery group then performance should be better than for the pure implicit and explicit groups. If the implicit and explicit processes interfere with each other then the discovery group should perform worse than the pure implicit and explicit groups.

## Method

### *Participants*

Sixty-nine undergraduate students at the University of Flensburg (31 female, 38 male; mean age 24.1; range 19 to 29 years old) were randomly assigned to four groups (an implicit group [n=16], an explicit group [n=17], a discovery group [n=16], and a control group [n=20]). The participants had no basketball experience equal to, or beyond, the sports club level. All participants in this study provided informed consent.

### *Apparatus and Material*

The situation used in this experiment is called “center-rotation” in basketball: the right-guard player possesses the ball and has four options – pass to the rotating center, pass to the post, pass to the playmaker, or shoot to the basket. Experts were consulted to define the “if-then” rules so that only one option was correct in each variation of the defined situation. Video clips of the IF-THEN scenarios were selected through four validation procedures that included two expert ratings, an item analysis, and external validation.

A Heidelberg Video test for tactical Decisions (HVD) was used (Raab, 2003). At the end of each video clip, prior to the decision of the right-guard player, the video scene was frozen for one second. Participants had to stand (straddle) on two ground mats in a ready position from which they had to move to one of four ground mats in front of them that represented the four options (shoot to the basket, pass to the playmaker, pass to the center, pass to the post). Ground mats were connected to an computer to measure decision time in milliseconds and identify the options chosen by the participants.

### *Procedure*

*Practice.* The training took place over a four-week period in four sessions of two hours each (one session per week) to mirror the learning procedures of beginners in real sports situations. The procedure for all treatment groups differed only in terms of the instructional set.

*Explicit group.* At the beginning of each training session, the explicit learning group watched the coach visually presenting each of four “if-then” rules on a tactic chart. The group then practiced the rules 50 times in two subgroups. Another coach organized the rotation of positions in these subgroups to ensure that each player had the same amount of practice for each rule and each position in attack and defense teams.

*Implicit group.* Implicit learners listened to instructions that informed them that they were taking part in a memory test for defense players. They were instructed to memorize 5 out of every 10 decisions the right wing player was taking in a partial-recall test (decisions 1 to 5, or 6 to 10). In two subgroups the right wing player was a basketball player who was informed to follow the four rules in a random order. A second coach rotated the players after 10 attacks and chose randomly one of the participants to recall either the chosen options 1 to 5 or 6 to 10 of the right wing player.

*Discovery group.* The discovery learners read instructions that guided them to discover the underlying rules for the situation “center rotation”. They were asked after each 10 attacks to search for potential rules of their own and at the end of each session they were asked to write down the rules that they perceived to be informative for beginners in an if-then system.

*Control group.* The control group did not take part in the learning; they participated only in the test to ensure a baseline for decision making in the test.

*Testing.* Two tests were run after the training sessions to check the efficiency of the different treatments in tactical decisions. The first, which occurred one day after the last training session, was an indirect test to measure decision quality and decision time. This test involved the use of the HVD for tactical decisions. The instruction on how to decide on options was balanced for speed–accuracy effects.

The second test, which was given four weeks after the last training session, was a retention test in which no feedback was received. The retention test was identical to the post test, in that the same video clips were shown. The procedure of the post test was repeated for the retention test; except for a questionnaire for explicit knowledge presented at the end of the retention test, and debriefing at the end of the session. After a warm-up period of 20 scenes, the HVD involved 50 played situations.

A questionnaire at the end of the retention test, with both open-ended questions (recall) and a multiple choice section (recognition), revealed the real purpose of the learning sessions and assessed whether the participants were able to verbalize the structure of the situations given. For the recognition of knowledge a forced-choice test was presented in which IF statements had to be completed by one THEN statement out of four given. For recall participants were asked to describe how and why specific decisions were made. All recall answers were transformed into a scale of qualitative knowledge about the structure of the situation (0 to 3, where 3 means the maximum) and a scale of knowledge (Likert scale 0 to 9, where the maximum is 9) by recognition. The scale for qualitative knowledge was built by the transformation of the participants’ answers (expert analysis), based on whether they could be attributed to a correct description of a rule or not.

### Results

#### *Choices and decision time*

Two 4×2 ANOVAs (groups × tests) with repeated measures on the last factor were run for decision quality and decision time indicating a main effect for decision quality ( $F(3,66) = 58,37$ ,  $p < .05$ ,  $\eta^2 = .74$ ) and decision time ( $F(3,66) = 8,98$ ,  $p < .05$ ,  $\eta^2 = .13$ ). There was no main effect on tests or a significant interaction between groups and tests. Post-hoc analysis (Scheffé) revealed that the explicit groups were superior to the implicit and discovery group in the quality of choices in post test and retention. The control group did not deviate from chance and performed significantly worse compared to the other groups in decision quality. The discovery group was faster than the implicit and the explicit group. No other effects reached significance.

#### *Explicit Knowledge*

The analysis of the questionnaires revealed better recall performance by the explicit group, followed closely by the discovery group compared to the implicit group. An ANOVA with groups for recall performance showed a significant main effect ( $F(3,65) = 3,04$ ,  $p < .05$ ). Post-hoc analysis (Scheffé) indicates that this effect was due to the difference between the implicit group and both, the explicit and the discovery group. No differences are found between the explicit group and the implicit group. There were no significant group differences for recognition performance.

#### Conclusions

The explicit group choices were better than the choices of the implicit and discovery group in the video test. In addition, the explicit group verbalized most rule knowledge, followed closely by the discovery group. The implicit group had almost no knowledge to recall.

More detailed analyses of the HVD were carried out to ensure that the treatment of the implicit group resulted in implicit learning. The choices for each situation that represent the same if-then rule were merged and group differences indicated that differences between groups were mainly due to different quality of choices for two rules (rule 1 and rule 4) whereas the two rules in which the groups differed in their recall knowledge most were rule 2 and rule 3. This finding indicates that knowledge and behavior is mostly unrelated. Furthermore, the implicit learning was robust against forgetting, which could be shown by the absence of a significant decrease in decision quality from the post test to the retention test after a further four weeks.

Based on the recall data it seems plausible to assume that discovery learning is more guided by explicit processes given the amount of verbalizable knowledge the discovery group accumulated. It may be the case that simply a speed-accuracy trade-off is present such that discovery learners are faster and therefore poorer in choice quality. It is unclear whether interference between implicit and explicit processes in the discovery group led to poorer choices, although a positive interaction between the processes can be ruled out.

The results indicate that discovery learning is based more on explicit knowledge than implied by Williams et al. (2002). The discovery learning protocol resulted in increased hypothesis testing and verbalizable knowledge (Liao & Masters, 2001). In addition, discovery learning leads to poorer, faster choices. Before practical applications are drawn for instructions in sports we need to understand more the mechanisms and the conditions in which implicit, explicit and discovery learners perform well or poorly.

#### References

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