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Abstract

Two studies examined whether simple algebraic rules that have been shown to be operative in many applied settings may also be found in sport decision-making. The theoretical framework for these studies was the Functional Theory of Cognition (Anderson, 1996). The way in which novices but already experienced team sport players (soccer, basketball, and handball players) combine different informational cues (relative importance of the game, numerical status of the team, current score, and time left to play) for deciding a quick restart of play near the end of a match was examined. The basic finding are consistent with the proposition that the knowledge bases at work for judging the appropriateness of this type of sport decisions are structured according to simple algebraic rules.

Cognitive Algebra in Sport Decision-Making

The many studies to date that have examined judgment and decision-making within the framework of the Functional Theory of Cognition (Anderson, 1991, 1996) have shown that simple algebraic rules may often account for the way various pieces of information are combined. This has led Anderson (1996) to propose the concept of cognitive algebra. The usual rules of cognitive algebra include adding (Girard & Mullet, 2002), averaging (Guillet, Hermand & Mullet, 2002), multiplying (Léoni, Mullet & Chasseigne, 2002), and many other conjunctive or disjunctive rules (Karpowicz-Lazreg & Mullet, 2001, Hermand, Mullet & Lavieville, 1997). These simple rules have been shown to be operative in laboratory conditions as well as in applied settings. Examples of applied settings in which this kind of approach has been successfully implemented include situations as different as cardio-pulmonary resuscitation (Sorum, Muñoz Sastre, Mullet & Gamelin, 1999), interpersonal forgiveness (Azar, Mullet & Vinsonneau, 2000), electricity circuits (Liégeois, Chasseigne, Papin & Mullet, 2003), end-of-life preferences (Frileux, Muñoz Sastre, Mullet & Sorum, 2003), music enjoyment (Makris & Mullet, 2003), addictive behavior (Munoz Sastre, Mullet & Sorum, 2000), area measurement (Rulence-Pâques & Mullet, 1998), family life satisfaction (Macri & Mullet, 2003), and stress appraisal (Guillet, Hermand & Mullet, 2002) to quote only a few ones. The present set of studies was aimed at examining whether these simple algebraic rules may also be found in sport decision-making.

Experts, Novices and Decision-Making Schemata in Sport

In the domain of sport and exercise (team as well as individual), expertise has largely been explained by superiority in perceptual and cognitive processes related to the specific-knowledge bases available. As an example, Helsen and Starkes (1999) examined the relative importance in the determination of expertise in soccer of (a) attributes determined by the efficiency of the visual/central nervous system, and (b) attributes determined by cognitive domain-specific skills (e.g., complex decision speed and accuracy, and number of visual fixations in solving game problems). They found that the only significant predictors of sport performance were the cognitive domain-specific skills (see also Starkes, Allard, Lindey & O'Reilly, 1994). Studying cognitive factors involved in planning strategies, McPherson (2000) showed that expert tennis players generated more varied and more sophisticated goals and actions than novices. Experts planned for actions based on elaborate goals that are specific to sport situations, whereas novices lacked these cognitive structures to plan their action (see also Vom Hofe, 1995, for a discussion of skill specificity in complex athletic tasks). Lerda, Garzunkel and Therme (1996) have shown that experts were better than novices at adapting their responses to a standardized one-to-one task in soccer that was presented according various spatial constraints. These authors proposed the existence of schemata that organized information processing towards the relevant characteristics of the task. These schemata were conceived as expectation systems with invariant knowledge about the specificity of the situation. However, no indication was given in these studies concerning the possible content of these schemata among novices and among experts, and their organization (Starks, Helsen & Jack, 2001).

Despite the importance that has been attributed to these knowledge bases for explaining how novices and experts perform (and why experts perform better than novices), the way in which these knowledge bases are structured has not received much attention (Thomas & Thomas, 1994). During a match, athletes must process more or less at the same time many kinds of information: the opponent's position, the team organization, the time constraint, the current score, and many other cues. The way the athletes decide "what to do" (Rink, French, Tjeerdsma and Bonnei, 1996); that is, the athletes' concrete decision, is a function of these various pieces of information, and also a function of their expertise. One possible factor responsible for sport performance might be the degree of organization and integration of this knowledge in more or less efficient decision-making schemata, as suggested by Lerda et al. (1996). As most decisions are made under stress and time pressure, the quality of these decision schemata plays an important role because appropriate schemata allow players to quickly and efficiently plan and program the movement with correct speed and precision before execution. What is the structure of these decision schemata? Which cues are considered determinant? Which rule is used to combine these cues?

This is these types of questions we examined in the current study as regards one concrete strategy in soccer matches: quick restart of play at the end of a match. Quick restart is, for example, a strategy often enacted when the opposite team has just scored a goal. It consists in deciding to put the ball back into play as quickly as possible in the hope of preempting defensive action from the opposite team; that is, acting before the defense has been able to re-organize. This strategy involves risks. The major risk is the possibility of losing the ball when increased speed of play tends to reduce the precision of passes between partners.

The choice of soccer was guided by the fact that this sport is one of the most popular in Europe; as a result it was easy to select from a wide population of experienced (if not experts) players. The choice of the quick restart of play at the end of a match was suggested by the sportsmen themselves: It is a tactic decision for which tangible rules appear to exist (Dracon, 1999). It is a complex decision which must take into account circumstances and various events which have occurred during the game: relative importance of the game, current numerical status of the team, score at the time of the decision and time left to play.

Some Possible Combination Rules and How to Recognize Them

As stated before, the theoretical and methodological framework for our study was the Functional Theory of Cognition. We have chosen this framework because the basic aim of this theory is to define the laws of information processing and the integration of multiple stimuli which accurately characterize the relationships between information presented to participants (here, current status of the team, current score) and the subjects' judgements (of appropriateness of a quick restart of play decision at the end of a match). A similar framework has already been used in sport decision-making by Vergeer and Hogg (1999) who analyzed coaches' decisions about an injured athlete's participation in competition as a function of several situational factors (injury severity, the gymnast's age, ability level and importance of the competition) they systematically varied in an orthogonal design. In order to better understand the objectives of the study, the methodology used, and the possible rules under consideration, some concrete examples will now be analyzed in detail. The examples of rules presented are the ones useful for the study.

Suppose a participant is presented with a series of nine play situations defined by a current team numerical status and a current score. There are three different team numerical status (numerical inferiority – as during a penalty situation, equality, and numerical superiority), and three different current scores (losing, tie or winning). Suppose this participant is asked to judge each play situation from the standpoint of the appropriateness of a quick restart of play decision at the end of a match. Once the ratings are obtained, they are plotted as a factorial graph of the type shown in Figure 1. On the vertical axis is the judged appropriateness given the play situation. On the horizontal axis are the three possible current scores. Each curve corresponds to one current team status.

The pattern of results shown in (a) presents a series of clearly ascending curves, but these curves are merged. From this pattern it is possible to state that the more unfavorable the score, the more appropriate the decision, and also that the specific current team status was not taken into account in judging the appropriateness of the decision. The participant has taken into account only one feature of the situations for judging -- the current score, and has judged according to his/her appropriateness values for the different scores. An ANOVA conducted on the raw data should show a significant effect for the Score factor. All other effects should be non-significant.

Insert Figure 1 about here

The pattern of results shown in (b) illustrates a rule which, by contrast with (a), truly deserves to be called a combination rule. It presents a series of ascending curves, but these curves are clearly separated. From this pattern it is possible to state that the more unfavorable the score, the more appropriate the decision, and the more favorable the numerical status of the team; that is, when the other team is in a penalty situation, the more appropriate the decision. The participant has taken into account both features of the situation for judging. However, one more characteristic of the pattern of results shown in (b) deserves consideration: The curves are parallel. This is important information for assessing the combination rule used to integrate current score and team information into an overall appropriateness judgment. Parallelism of curves is the result of an underlying additive-type process. An ANOVA conducted on the raw data should show a significant effect for the Score factor, and for the Team factor. All interaction effects should be non-significant.

The pattern of results shown in (c) serves to introduce a cognitively more complex combination rule. The main difference with the pattern shown in (b) is that the curves are not parallel. They form a fan open to the right. This is again an important cue for assessing the combination rule used to integrate score and team information. An ANOVA conducted on the raw data should show a significant effect for the Score factor, for the Team factor, and for the bilinear component of the Score x Team interaction. The other components of the interaction should be non-significant.

Non-parallelism of curves is usually the result of an underlying non additive-type process. What is reflected in the pattern shown in (c) is that the effect of the team status varies as a function of the current score. When the score is favorable, the vertical distance between the three points corresponding to the three team numerical status is reduced, in relation with the corresponding vertical distance observed when the score is unfavorable. In other words, the impact of team numerical status is under the influence of the current score. When the score is favorable it is given heavy weight, and the relative weight of team numerical status is proportionally reduced. Consequently, the overall appropriateness rating is always relatively low (from 1 to 4 in the figure), quite irrespective of the team numerical status.

The pattern of results shown in (d) is symmetrical with the one just analyzed. It forms a fan open to the left. As regards the underlying process, the only difference between the two patterns is that in (d), the weight of the current score is a direct function of its favorableness. As a result, the overall appropriateness value is always relatively high (from 10 to 13 in the figure), quite irrespective of the current score.

The pattern of results shown in (e) presents both sets of characteristics of the patterns shown in (c) and in (d). The left part of this pattern is similar to the pattern shown in (c). The right part of the pattern is similar to the pattern shown in (d). As regards the underlying process, the only difference between (e) on one hand, and (c) and (d) on the other hand, resides in the form of the function linking the weight given to the score and the favorableness of the score. In (c) and (d) this function was monotonic. In (e), the function is no longer monotonic. When the score takes the win or the lose values, its weight is more important than when its takes the tie value. An ANOVA conducted on the raw data should show a significant effect for the Score factor, for the Team factor, and for the linear x quadratic component of the Score x Team interaction. The other components of the interaction should be non-significant.

Finally, the pattern shown in (f) also presents both sets of characteristics of the patterns shown in (c) and in (d). The right part of this pattern is similar to the pattern shown in (c). The left part of the pattern is similar to the pattern shown in (d). As regards the underlying process, the only difference between (f) on one hand, and (c) and (d) on the other hand, also resides in the form of the function linking the weight of the score and its favorableness. When the current score takes the tie value, its weight is more important than when its takes the win or the lose values. An ANOVA conducted on the raw data should show a significant effect for the Score factor, for the Team factor, and for the linear x linear component of the Score x Team interaction. The other components of the interaction should be non-significant.

Study 1

Method

Participants

The participants are 100 volunteers living in the North of France. They were all male members of soccer teams. Their age varied from 18 to 25 years. The average time they had been with a team was 4 years 1 month; that is, they were still novices although they had already considerable experience.

Material

The material consisted of 36 cards showing a short scenario of about four lines and a response scale. Each scenario contained four critical items of information in the following order: (a) the relative importance of the game (friendly match vs. competition match), (b) the current numerical status of the team (numerical inferiority – one player less than in the opposite team, or equality, or numerical superiority – one player more than in the opposite team), (c) the current score (loss or tie or win), and (d) the time left to play (little time versus very little time). All possible combinations of these types of information yielded 2 x 3 x 3 x 2 = 36 scenario. One typical scenario is the following: «Your team is playing a championship match. At present, your team's score is one goal more than the other team's and your team has one player more than the opposite team. The ball has left the playground. Very little time remains to play. Will you decide to quickly restart the play?».

Beneath each scenario was a 20-cm response scale with "Completely Sure I will decide a quick restart of play" indicated at the left and "Completely sure I will not decide a quick restart of play" indicated at the right.

Procedure

The participants were interviewed in 2000. According to the methodology in FTC (Anderson, 1996), the test was administered in two phases. Participant responded individually, generally during sport training or in sport club meetings. The researcher explained to participants their role in the study, in the first or familiarization phase, in which participants would read a certain number of scenarios indicating that during a match, a player must decide whether a quick restart of play strategy has to be adopted or not. Their task was to identify with this player and express an opinion about the appropriateness of this kind of decision in each case. In this initial phase, each participant was presented with the 36 scenarios. Each scenario was read aloud by the participant. Subsequently, participants provided the required ratings and were given an opportunity to compare their responses and change them.

During the following experimental or second phase, the 36 scenarios were resubmitted to participants in a different order. Participants provided their ratings at their own pace and were not allowed to compare responses or to go back and make changes as in the familiarization phase.

Results

Participants' ratings from the second, experimental phase were converted to a numerical value expressing the distance (measured with a ruler) between the point on the response scale, and the left anchor that served as the point of origin. These numerical values were then subjected to graphical and statistical analyses.

Insert Figure 2 about here

The Score effect clearly was the dominant effect, $F(2, 198) = 1181.83$, $p < .0001$. The other three effects were, however, significant, $F(2, 198) = 322.98$, for Team, $p < .0001$, $F(1, 99) = 9.62$, for Importance, $p < .003$, and $F(1, 99) = 7.86$, $p < .007$, for Time. Figure 2 shows five of the six 2 x 2 combinations of the four factors. On panel a, team values are posited along the horizontal axis, from numerical inferiority to numerical superiority. Each curve corresponds to one level of the relative importance factor. Judgments are plotted along the vertical axis. The general pattern is highly reminiscent of the pattern b shown in Figure 1; that is, team and relative importance factors appeared to be combined in an additive way. Some deviations from parallelism are perceptible in this panel but the Team x Importance interaction was not significant.

The other five panels were constructed in the same way. In panel b, the pattern of results was closely similar to the one shown in Panel a. Team and time factors appeared to be combined in an additive way. The Team x Time interaction was not significant. In panel c, the general pattern is reminiscent of pattern f shown in Figure 1; that is, current score and importance factors appeared to be combined in a non-additive way. The Score x Importance interaction was significant and concentrated in its bilinear component (86% of the interaction variance), $F(1, 99) = 93.53$, $p < .0001$. When the game was very important (competition match), the current score effect was stronger than when the game was not very important (friendly match). In panel d, the pattern of results was closely similar to the one shown in Panel c. Score and time factors appeared to be combined in a non-additive way. The Score x

Time interaction was significant and concentrated in its bilinear component (99% of the interaction variance), $F(1, 99) = 97.21$, $p < .0001$. When there was very little time left to play, the current score effect was stronger than when there was little time.

In panel e, the pattern of results was closely similar to the one shown in Panel e of Figure 1. Team and score factors appeared to be combined in a non-additive way. The Team x Score interaction was significant, and concentrated in its linear x quadratic component (94% of the interaction variance), $F(1, 99) = 512.31$, $p < .0001$. When the team was winning or losing, the effect of the current status of the team (numerical inferiority or numerical superiority) was much weaker than when the current score was the same for both teams. Panel f shows the same results as pattern e but displayed in a symmetrical way, in order to make easier its interpretation. There were no significant higher order interactions.

Discussion

The various algebraic judgment rules already found in many applied settings were found to be operative in the particular sport decision-making situation examined in Study 1: Deciding a quick restart of play. Notably, simple adding, multiplying and averaging rules were clearly at work.

As regards the importance of each factor and the way they combine their effect in this situation, the Score factor appeared as the more important factor; it was mainly as a function of the current score that the decision of a quick restart of play was judged appropriate. The level of importance and the time left to play essentially played a moderating role. Finally, the current score clearly commanded the effect of the current status of the team.

Study 2

Study 2 was aimed (a) at replicating the results observed in Study 1 and (b) at comparing these results with the ones observed in two other different sport situations: the one represented by handball and the one represented by basketball. The question was: To what extent the simple integration rules found in Study 1 may also be found in sport settings different from the soccer one?

Very few studies have comparatively examined the perceptual and cognitive processes involved in different sports (for an exception see, Kioumourtzoglou, Kourtessis, Michalopoulou & Derri, 1998). As soccer, basketball, and handball are collective sports for which some cues (e. g., relative importance of the game) and some decisions (e. g., quick restart to play) are common and have the same meaning, it should be interesting to examine whether (or not) these cues are integrated in the same way for judging the appropriateness of a common decision in all three sports.

Method

The participants were 186 volunteers living in the North of France. They were all male and their age varied from 18 to 25 years. Sixty-six were members of soccer teams (mean number of years of experience = 5 years and 2 months). Sixty were members of basketball teams (mean number of years of experience = 5 years and 4 months). Sixty were members of handball teams (mean number of years of experience = 4 years and 5 months).

The material and the procedure were the same as in Experiment 1. Soccer players were presented with scenarios depicting soccer games. Basketball players were presented with scenarios depicting basketball games. Handball players were presented with scenarios depicting handball games. The only difference was about the time left to play factor which two levels were adapted to reflect what is usually considered as little time and very little time in handball and basketball. The data were collected in 2001.

Results

As regards Soccer, the pattern of main effects was very similar to the one found in Study 1: The score effect and the team effect were clearly the dominant factors. As regards basketball, the score effect and the team effect were the dominant factors but the pattern of effects was more balanced. Time left to play and importance of the game had a non-negligible effect. As regards handball, the pattern of main effects was more dissimilar to the one for Soccer. Score was the dominant factor but Time had a stronger effect than Team. All the differences commented are supported by significant effects: $F(4, 366) = 52.39$, $p < .0001$, for the Sport x Score interaction, $F(4, 366) = 9.86$, $p < .0001$, for the Sport x Team interaction, $F(2, 183) = 113.91$, $p < .0001$, for the Sport x Time interaction, and $F(2, 183) = 19.51$, $p < .0001$, for the Sport x Importance interaction.

Insert Figures 3 about here

Figure 3 shows, for each sport, three of the six 2 x 2 combinations of the four factors, the ones that correspond to panels b, c, and e in Figure 3. Panel a is constructed in the same way as panel b in Figure 3. The pattern of results is highly similar to the one already shown in Study 1; that is, team and time factors appeared to be combined in an additive way. In panels b and c, however, the pattern of results is very different of the one shown in a. The pattern of results in panel b is highly reminiscent of the one shown in panel d in Figure 1. When time left to play was very short, a quick restart of play decision appeared appropriate, irrespective of the current team status. When there was more time to play, the appropriateness of this decision depended on the current team status. The pattern of results in panel c is original. When time left to play was very short, a quick restart of play decision never appeared very appropriate. When there was more time to play, the appropriateness of this decision strongly depended on the current team status. When the team was numerically equal or superior, a quick restart of play decision appeared more appropriate. When the team was numerically inferior, however, a quick restart of play decision appeared less appropriate than in the cases where the time left to play was very few. These differences in patterns of results were supported by a significant Sport x Team x Time interaction: $F(4, 366) = 66.37$, $p < .0001$.

Panel d is constructed in the same way as panel c in Figure 3. The pattern of results is highly similar to the one already shown in Study 1; that is, score and importance factors appeared to be combined in a non-additive way. When the game was a very important one, the score effect was stronger than when the game was not a very important one. In panels b and c, however, the pattern of results is different from the one shown in a. In panel b, the pattern of results is reminiscent of the one shown in panel e, Figure 1. An effect of the relative importance of the game was only observed when the score was tied. In panel c, the pattern of results was reminiscent of panel b in Figure 1. Importance and score appeared to be combined in an additive way. There was another difference between panel e and panel f: The direction of the importance effect was not the same. These differences in patterns of results were supported by a significant Sport x Score x Importance interaction: $F(4, 366) = 50.15$, $p < .0001$.

Panel g is constructed in the same way as panel e in Figure 3. For the third time, the pattern of results is highly similar to the one already shown in Study 1; that is, team and score factors appeared to be combined in a non-additive way. When the team was winning or losing, the effect of the current status of the team was weaker than when the score was tied. In panels b and c, however, the pattern of results are different from the one shown in g, and more reminiscent of panel b in Figure 1. For basketball as well as for handball, team and score appeared to be combined in an additive way. There was, however, a difference between panel e and panel f. In panel f, the two higher curves were merged; that is, numerical equality and numerical superiority were not distinguished. These differences in patterns of results are supported by a significant Sport x Score x Team interaction: $F(8, 732) = 10.47$, $p < .0001$.

As regards the other three 2 x 2 combinations, results were of the same form in the three conditions. The Importance x Team interaction was never significant. The patterns of results were similar to the one shown in Figure 1, panel a. In each of the three sport conditions, team and importance factors appeared to be combined in an additive way. The Score x Time interaction was always significant, $F(2, 130) = 138.84$, for soccer, $F(2, 118) = 251.19$, for basketball, and $F(2, 118) = 125.33$, for handball ($p < .0001$ in each case). The patterns of results were similar to the one shown in Figure 1, panel d. In each of the three sport conditions, team and importance factors appeared to be combined in a non-additive way. When there was very little time left to play, the score effect was stronger than when there was more time. In addition, the Sport x Score x Time interaction was significant, $F(4, 366) = 74.82$, $p < .0001$. The variation of the effect of Score as a function of time was stronger in the case of basketball than in the other cases. Finally, the Importance x Time interaction was never significant.

Discussion

The basic result found in Study 1; that is, the combination rules at work were structured along simple algebraic operations (as exemplified in Figure 1) was replicated in Study 2. For basketball and handball, the patterns of results showed both similarities and differences with the ones found for soccer. In all cases, the score factor was the most important one, and the team factor played an important role. The observed differences were mainly about the importance of the time factor and the numerous interactions it had with other factors.

Given the way the sample was constituted (a convenience sample), it must be stressed that the value of the present study is not in precisely estimating the size of the effect of importance or the size of the effect of current score on the appropriateness of a quick restart of play decision during a match among novices (but experienced) sportsmen in general but in showing (a) the feasibility of the technique used for analyzing judgment and decision-making in the domain of sport, (b) in adding evidence about the generality of the algebraic rules already found operative in a variety of other applied settings, and (c) in bringing some light about the way novice sportsmen's knowledge bases may be structured. Athletes' relative skill level and experience with the game were not precisely assessed in this study: Future work should also take these factors into consideration. Notably, "capturing" experts' rules, through the kind of device used in the present set of studies, in view of knowing the "absolute" appropriateness value of a quick restart of play decision under diverse circumstances and the way they vary as a function of these circumstances would be an interesting objective.

Simulation and Reality

Both studies showed a pattern of differences in judged levels of appropriateness associated with diverse conditions. It is possible, therefore, that there is a somewhat different pattern of actual probabilities with which quick restart of play decision would be implemented during real games when the very same conditions are concretely encountered. In fact, it is the epistemological status of simulation studies that is questioned here. It is obvious that research based on observable behavior has an indisputable ecological validity. However, the design of these studies, and the correlation methods generally used rarely allow precise comparative tests between various combination rules, above all when these rules suppose complex relationships between factors (see panel e in Figure 2). On the other hand, simulations as in the present study, if they do not claim to the same level of ecological validity, are generally adequate to precisely test combination rules. They are considerably easier to conduct and their first results can guide the conduct of studies based on behavior, studies that are usually more extensive and costly. With regard to the current type of study, we believe that the two approaches are useful and complementary, and that their simultaneous or sequential implementation has its own merit. As an example, the simulation-then-reality approach is the only one that allows differences between what is observed in simulation conditions and what is observed under real play conditions to be a object of investigation in itself: What are the factors that can give account of these differences? What concrete factor in the real play condition “blocks” a decision that, otherwise, was judged highly appropriate? What concrete factor in real play conditions “triggers” the implementation of a decision that was, otherwise, judged inappropriate? These questions are real ones, and deserve close scrutiny.

References

Anderson, N. H. (1991). *Contributions to information integration theory*. Hillsdale, NJ: Erlbaum.

Anderson, N. H. (1996). *A functional theory of cognition*. Mahwah, NJ: Erlbaum.

Azar, F., Mullet, E. & Vinsonneau, G. (1999). The propensity to forgive: Findings from Lebanon. *Journal of Peace Research, 36,* 169-181.

Dracon, N. (1999). *La prise de décision au rugby* [Decision-making in rugby]. Caen: Université de caen, thèse de doctorat.

Frileux, S, Lelièvre, C., Muñoz Sastre, M. T., Mullet, E., & Sorum, P. (2003). Deciding to end a patient's life. *Journal of Medical Ethics,* in press.

Girard, M., Mullet, E., & Calahan, S. (2002). Mathematics of forgiveness. *American Journal of Psychology, 115,* 351-375.

Guillet, L., Hermand, D., & Mullet, E. (2002). Cognitive processes involved in the appraisal of stress. *Stress and Health, 18*, 91-102.

Helsen, W. F., & Starkes, J. L. (1999). Multidimensional approach to skilled perception and performance in sport. *Applied Cognitive Psychology*, *13*, 1 –27.

Hermand, D., Mullet, E. & Lavieville, S. (1997). Estimation of the combined effect of tobacco and alcohol on cancer risks. *Journal of Health Psychology, 2,* 481-491.

Karpowicz Lazreg, C., & Mullet, E. (2001). Judging the pleasantness of form-color combinations. *American Journal of Psychology, 114*, 511-533.

Kioumourtzoglou, E., Kourtessis, T., Michalopoulou, M. & Derri, V (1998). Differences in several perceptual abilities between experts and novices in basketball, volleyball, and water-polo. *Perceptual and Motor Skills, 86,* 899-912.

Léoni, V., Mullet, E. & Chasseigne, G. (2002). Aging and Intuitive Physics. *Acta Psychologica*, *111,* 29-43.

Lerda, R., Garzunkel, R, & Therme, P. (1996). Analogic transfer: A strategy for adapting to spatial constraints: The case of a duel in soccer. *International Journal of Sport Psychology*, *27*, 133-145.

Liégeois, L. Chasseigne, G., Papin, S., & Mullet, E. (2003). Improving high school students' understanding of potential difference in simple electric circuits. *International Journal of Science Education, 25*, 1-17.

Macri, D., & Mullet, E. (2003). Employment and family as determinants of anticipated life satisfaction among young Greek adults. *Community, Work and Family, 6,* 197-215.

Makris, I., & Mullet, E. (2003). Judging the pleasantness of contour-rhythm-pitch-timbre combinations. *American Journal of Psychology*, in press.

McPherson, S. L. (2000). Expert-novice differences in planning strategies during collegiate singles tennis competition. *Journal of Sport and Exercise Psychology*, *22*, 39-62.

Munoz Sastre, M. T., Mullet, E., & Sorum, P. C. (2000). Self-assessment of inebriation from external indices. *Additictive Behaviors, 25*, 663-681.

Rink, J.-E., French, K.E., & Tjeerdsma, B.-L. (1996). Foundations for the learning and instruction of sport and games. *Journal of Teaching in Physical Education, 15*, 399-417.

Rulence-Pâques, P. & Mullet, E. (1998). Perception of surface and inference of surface: The case of the rectangle. *Journal of Experimental Child Psychology, 69,* 1-27.

Sorum, P. C., Munoz Sastre, M. T., Mullet, E., & Gamelin, A. (2001). Eliciting patient disutilities for the adverse outcomes of cardiopulmonary resuscitation. *Resuscitation, 48*, 265-273.

Starkes, J.L., Allard, F., Lindley, S., & O'Reilly, K.. (1994). Abilities and skill in basketball. *International Journal of Sport Psychology*, *25*, 249-265.

Starkes, J. L., Helsen, W., & Jack, R. (2001). Expert performance in sport and dance. In Singer, R. N., Hausenblas, H. A & Janelle, C. M. (Eds.). *Handbook of Sport Psychology* (pp. 174-204). New York: Wiley.

Thomas, K. T., & Thomas, J. R. (1994). Developing expertise in sport: The relation of knowledge and performance. *International Journal of Sport Psychology*, *25*, 295-312.

Vergeer, I., & Hogg, J.-M. (1999). Coaches' decision policies about the participation of injured athletes in competition. *Sport Psychologist, 13*, 42-56

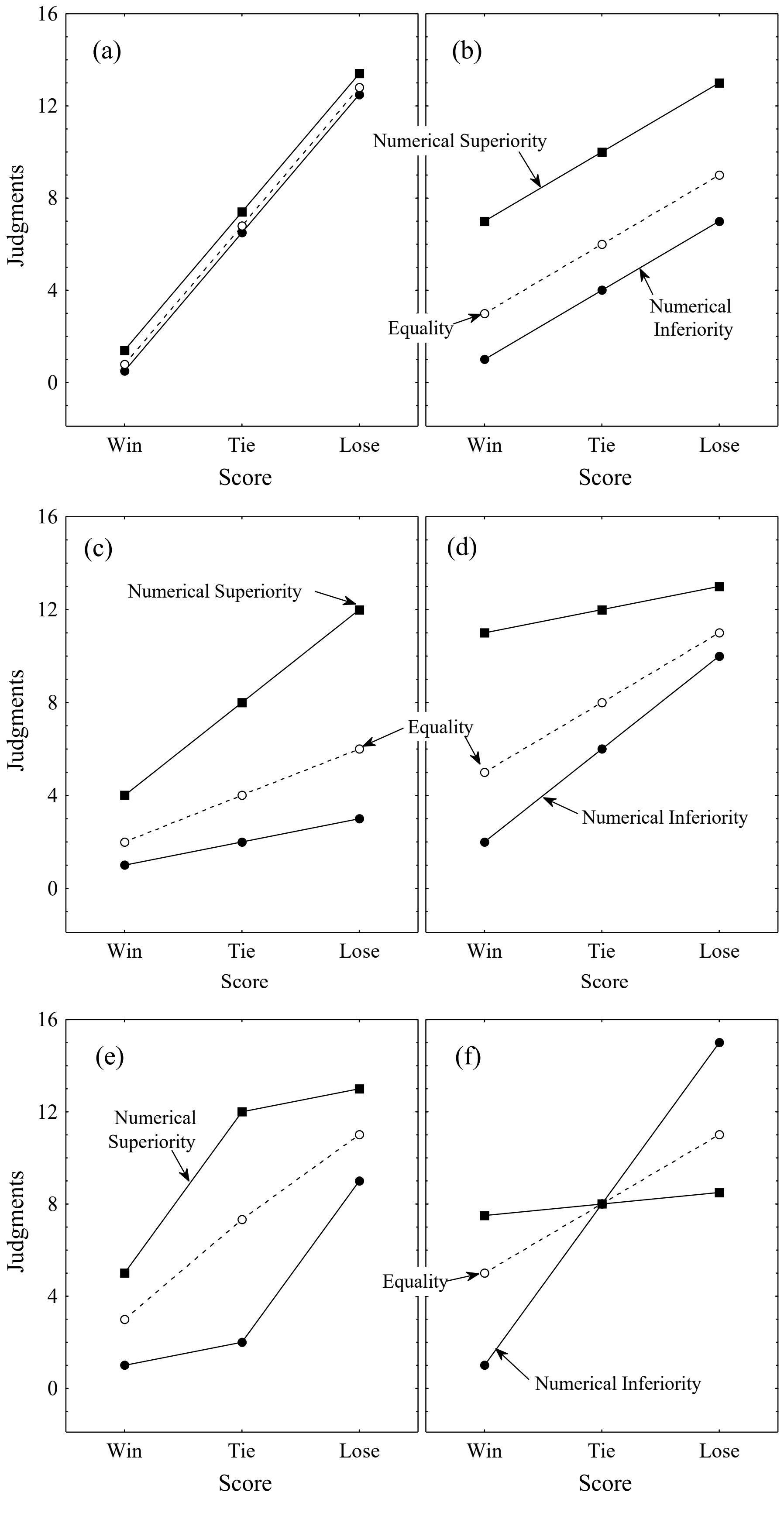
Vom Hofe, A. (1995). The problem of skill specificity in complex athletic tasks : A revisitation. *International Journal of Sport Psychology*, *26*, 249-261.

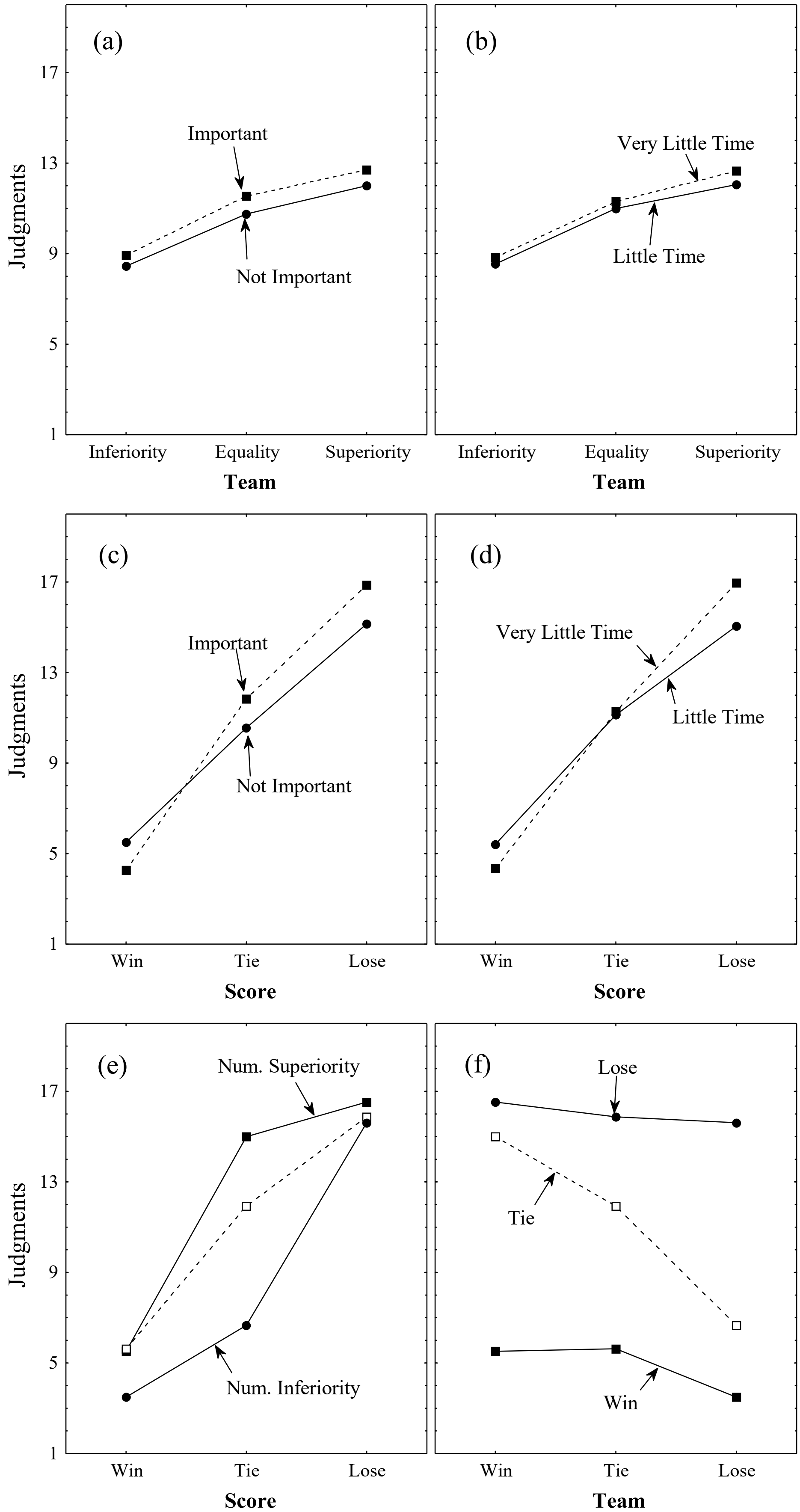
Figure Captions

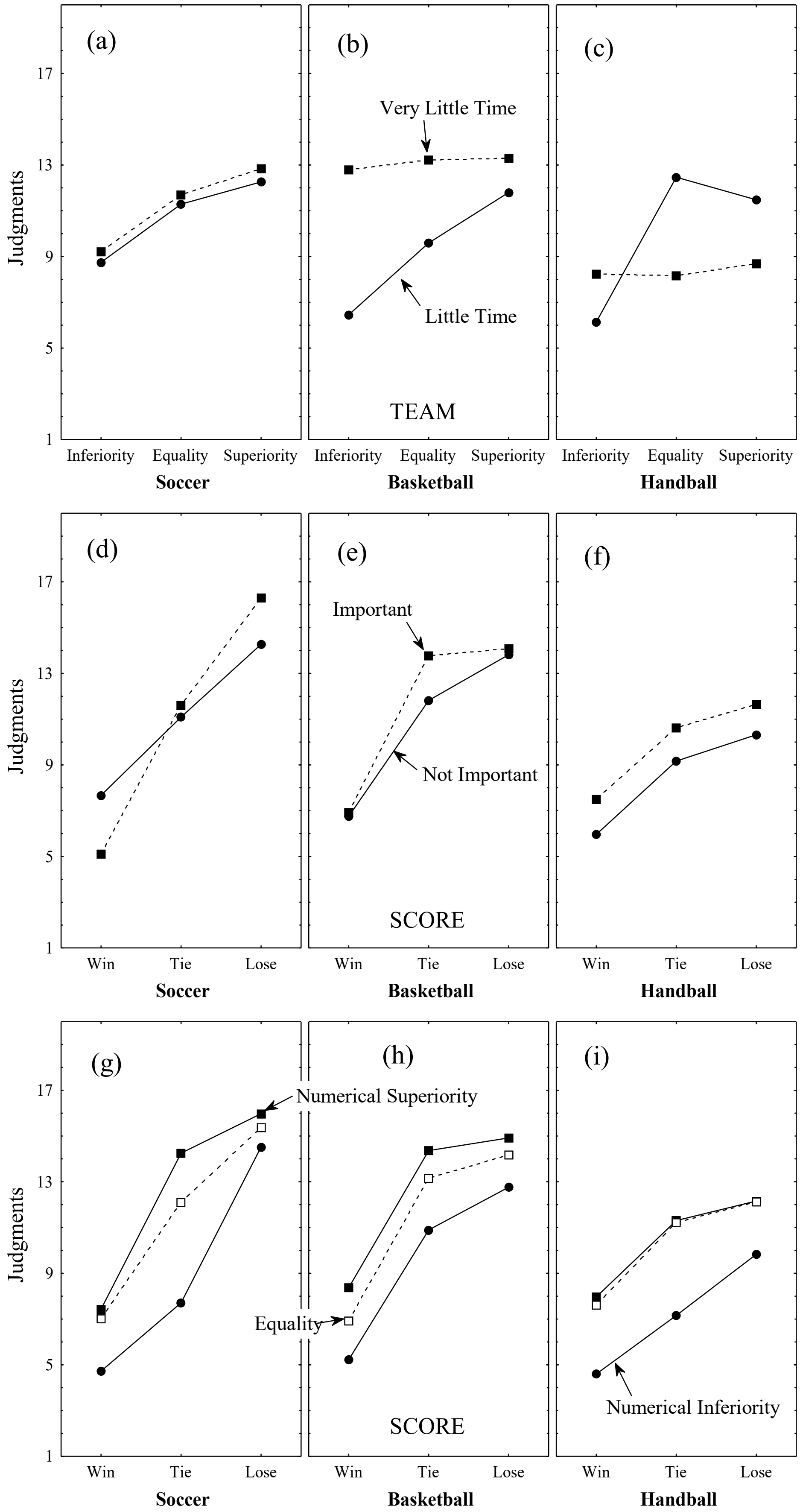
Figure 1. Typical patterns of data obtained with (a) unifactorial, (b) additive-type, (c) conjunctive, (d) disjunctive, (e) conjunctive-disjunctive, and (f) disjunctive-conjunctive integration rules.

Figure 2. Combined effect of (a) importance and team factors, (b) time and team factors, (c) importance and score factors, (d) time and score factors, and (e-f) team and score factors.

Figure 3. Combined effect of (a-c) time and team factors, (d-f) importance and score factors, and (g-i) time and score factors, for each of the three sports considered.


(a)
(b)
Numerical Superiority
Equality
Numerical
Inferiority
(c)
Numerical Superiority
Equality
(d)
Numerical Inferiority
(e)
Numerical
Superiority
(f)
Equality
Numerical Inferiority
Judgments
Score
Win
Tie
Lose
0
4
8
12
16


(a)
Important
Not Important
Judgments
17
13
9
5
1
Inferiority
Equality
Superiority
Team
(b)
Very Little Time
Little Time
Inferiority
Equality
Superiority
Team
(c)
Important
Not Important
Judgments
Win
Tie
Lose
Score
(d)
Very Little Time
Little Time
Win
Tie
Lose
Score
(e)
Num. Superiority
Num. Inferiority
Judgments
Win
Tie
Lose
Score
(f)
Lose
Tie
Win
Win
Tie
Lose
Team


(a)
(b)
(c)
Very Little Time
Little Time
TEAM
Judgments
17
13
9
5
1
Inferiority
Equality
Superiority
Soccer
Basketball
Handball
(d)
(e)
(f)
Important
Not Important
SCORE
Win
Tie
Lose
(g)
(h)
(i)
Numerical Superiority
Equality
Numerical Inferiority