Application of *ExpressDecision2* in User-Centered and Shared-with-Expert Decisions Under Risk and Uncertainty

Alexander M. Yemelyanov[1], Rahul Sukumaran[1], and Alina A. Yemelyanov[2]

[1]Georgia Southwestern State University, Americus, GA 31709, USA
[2]Georgia State University, Atlanta, GA 30303, USA

ABSTRACT

ExpressDecision2 (https://expressdecision2.com) is a general-purpose web application designed to support the individual in making difficult decisions under uncertainty, which are emotionally driven and typically solved by using rational intuition. In this work, the self-regulation model of this application is further expanded to help apply *ExpressDecision2* more efficiently to difficult decisions under uncertainty in scenarios dealing with healthcare ($ED^2StatinChoice$) and insurance ($ED^2InsuranceChoice$). We demonstrate that in the self-regulation model, the factor of difficulty creates anxiety, the factor of significance creates peace of mind, and both of them can be measured and included into the decision-making model: factor of difficulty as a successful negative outcome and factor of significance as an unsuccessful positive outcome.

Keywords: Mobile web application, Motivated decision making and problem solving, Risk and uncertainty, Self-Regulation, Factor of difficulty, Factor of significance, Performance shaping factors, Anxiety and peace of mind, Decision support systems, Decision aids

INTRODUCTION

ExpressDecision2 (https://expressdecision2.com) is a web application designed to support the individual in making difficult decisions under uncertainty, which are emotionally driven and typically solved by using rational intuition. This web app is based on the self-regulation model of the thinking process developed within the framework of the systemic-structural activity theory (G. Bedny, Karwowski, I. Bedny, 2015). *ExpressDecision2* can be used both for everyday and for professional decisions, and can be run on both desktop and mobile platforms, including smartphones. In this work, the self-regulation model is further expanded to help apply *ExpressDecision2* more efficiently to difficult decisions under uncertainty in scenarios dealing with healthcare ($ED^2StatinChoice$) and insurance ($ED^2InsuranceChoice$). These types of decisions under uncertainty are characterized by anxiety and peace of mind.

We consider anxiety a negative emotional state and peace of mind a positive emotional state, both of which are associated with future risk and uncertainty. For example, in healthcare, it is common for patients to

experience "anxiety" from wondering whether they will be able to endure a particular medical treatment (for example, to help lower their blood pressure). However, they may also experience "peace of mind" from recognizing how this medicine, even despite its potential risk for side effects, will ultimately help improve their health. In a case regarding insurance, an insured person's "anxiety" may stem from wondering whether they will actually receive the appropriate compensation guaranteed by their insurance company in the event of accidental loss (for example, if they experience loss of health). However, "peace of mind" for them may come from recognizing that paying the required insurance premium will ultimately provide them with financial protection in the future. We demonstrate that in the self-regulation model, the factor of difficulty creates anxiety, and the factor of significance creates peace of mind. Both these factors are intangible outcomes of the decision-making involved in the formation of the mental model; they help determine the level of motivation for achieving the goal. We also demonstrate how both factors can be measured, and how these factors finally contribute to the level of motivation for choosing an alternative.

SELF-REGULATION DECISION-MAKING AND PROBLEM-SOLVING

ExpressDecision2 implements the Performance Evaluation Process (PEP), which uses the self-regulation model of decision-making activity (A. M. Yemelyanov, A. A. Yemelyanov, 2019; A. M. Yemelyanov, 2019). This makes *ExpressDecision2* behaviorally comparable to the user, which increases decision advice acceptance. PEP includes the following three stages: decomposing the problem, evaluating alternatives, and making a decision. PEP implements two concurrently and dynamically running processes: formation of the mental model (FMM) and formation of the level of motivation (FLM) by using two regulators: *factor of significance* and *factor of difficulty* (G. Bedny, I. Bedny, 2019). The factor of significance provides feedforward control, and the factor of difficulty provides feedback control. Both factors contribute to the formation of the level of motivation.

The design strategy for FMM implements a divide-and-conquer algorithm (D&C) to construct a Decision Tree (see Figure 1). The divide-and-conquer technique uses a recursive breakdown approach in decision-making: decompose the problem into smaller sub-problems, solve them, and then recombine their results to solve the bigger problem. This division of the problem into sub-problems may span several levels deep until a basic (ad hoc) level of certainty will be reached, at which point the problem can be positively evaluated within the process of FLM. In other words, the problem will contain only those outcomes for which the decision-maker will be able to determine their respective positive (or negative) intensity and likelihood, which in turn, will allow to determine the positive (or negative) motivational level (preference). It should be noted that the efficiency of the divide-and-conquer algorithm increases when people apply hypotheses and split the problem into two *mutually exclusive hypotheses*.

In FMM, feedback control is based on the factor of difficulty and used to verify whether the current state of the individual's mental model is capable of
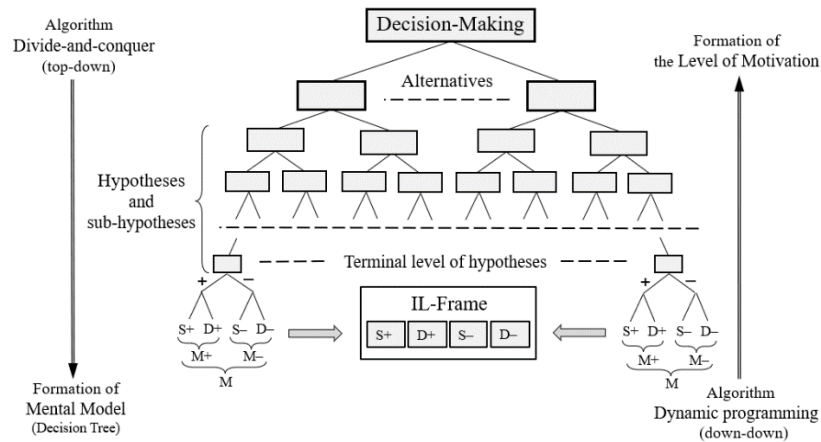
Figure 1: Performance Evaluation Process: decision hierarchy (decision tree) with IL-Frame.

either evaluating the problem or choosing the best alternative. The feedback is *positive* (+fb_FMM) when the individual can perform the verification, and *negative* (–fb_FMM) when the individual cannot perform it. When the feedback is negative, feedforward control (ff_FMM), which is based on the factor of significance, leads to an upgrade of the existing mental model. For this purpose, by considering various hypothetical situations and alternative solutions, the problem is divided into sub-problems, with corresponding sub-goals that help reduce existing difficulties of verification.

The design strategy for FLM implements a dynamic programming algorithm (DP). This algorithm determines the level of an alternative's motivation by evaluating its outcomes in IL-Frame and aggregating results with the help of K-Rules. IL-Frame is used as a template to evaluate outcomes, according to four *performance shaping factors* (PSFs): *positive significance S+* (presented by positive intensity $I+$), *positive component of difficulty D+* (positive likelihood $L+$), *negative significance* S– (negative intensity $I–$), and *negative component of difficulty D–* (negative likelihood $L–$).

K-Rules are relations between these PSFs which have been experimentally determined by M. Kotik (1994), with the purpose of defining positive $M+(I+, L+)$, negative $M–(I–, L–)$, and cumulative $M(M+, M–)$ levels of preference of outcomes, as well as combining these levels into a cumulative level of preference (motivation) for an alternative. IL-Frame uses verbal characteristics to measure the intensity (magnitude) and likelihood of outcomes on the verbal scales "weak – strong" and "seldom – often," respectively. This soft evaluation of outcomes enables better interpretation of an uncertain goal and conditions while improving decision accuracy. When measuring the motivational level of an alternative, the level of positive motivation (motivation to attain positive outcomes) and the level of negative motivation (motivation to avoid negative outcomes) are measured. The level of positive motivation is determined by the level of significance of positive outcomes and the level of difficulty in obtaining them, and the level of negative motivation is determined by the level of significance of negative outcomes and the level of

difficulty in avoiding them. With this in mind, the evaluation of significance of positive (negative) outcomes reflects the level (intensity) of their positive (negative) importance to the individual. Evaluation of difficulty depends on the valence of outcomes; for positive outcomes, it reflects the level of subjective possibility to attain these outcomes, and for negative outcomes, the level of subjective possibility to avoid them. Since the decision takes place in uncertain conditions regarding the outcomes, we assume that subjective possibility can be reflected by subjective perception/feeling of their likelihood.

ExpressDecision2 provides the user with two modes: decision-making and problem-solving. The *decision-making* mode helps make quick decisions on the fly, but this decision has a low level of instrumental rationality (accuracy). The decision is *problem-centered* and targeted to reach the *proximate* or *short-term goal*. For example, to save a patient's life, emergency physicians must decide rapidly whether a patient is at "high risk" for having a heart attack and thus needs to be sent to the "coronary care unit," or if they are at "low risk" and thus only need to be sent to a "regular nursing bed." The *problem-solving* mode requires setting goals and recognizing problems. Here, arriving at the decision (solution) is not as rapid as in the decision-making option, but its level of instrumental rationality (accuracy) is higher because it is supported by applying the *principle of instrumental rationality,* which was formulated by Yemelyanov in (Yemelyanov, Bedny, 2019). According to this principle, the goal of each sub-problem should be a sub-goal in order to help reach the main goal. The decision (solution) is *user-centered* and targeted to reach the short-term goal from the perspective of the long-term goal. For instance, the solution for reducing high cholesterol (short-term goal) by taking either low, high, or no dose of statins is made from the perspective of "high quality of life," which serves as the long-term goal.

There are two *motivation shaping factors* (MSFs) that determine the level of motivation for achieving the goal: the factor of significance (FS) and the factor of difficulty (FD). FD presents difficulties in achieving the goal and FS presents the significance of the goal. Both FS and FD determine the level of motivation for achieving the goal.

There are four *performance shaping factors* (PSFs) that determine the level of motivation for selecting the best alternative: *positive significance* (S+), *positive component of difficulty (D+), negative significance (S–),* and *negative component of difficulty (D–).*

The best alternative will be chosen based on the highest level of motivation. It's important to note that each motivation and performance shaping factor has information (cognitive-based) and energy (emotion-based) components, and that MSFs contribute to the value of PSFs (Yemelyanov, Bedny, 2020).

THE FACTORS OF SIGNIFICANCE AND DIFFICULTY

The goal in activity theory (G. Bedny, Karwowski, I. Bedny, 2015) has two components: *information (cognitive-based)* and *energy (emotion-based).* The first component splits outcomes into desirable (positive) and undesirable (negative). The second one splits outcomes, according to the factor of significance (FS) and the factor of difficulty (FD). The factor of significance
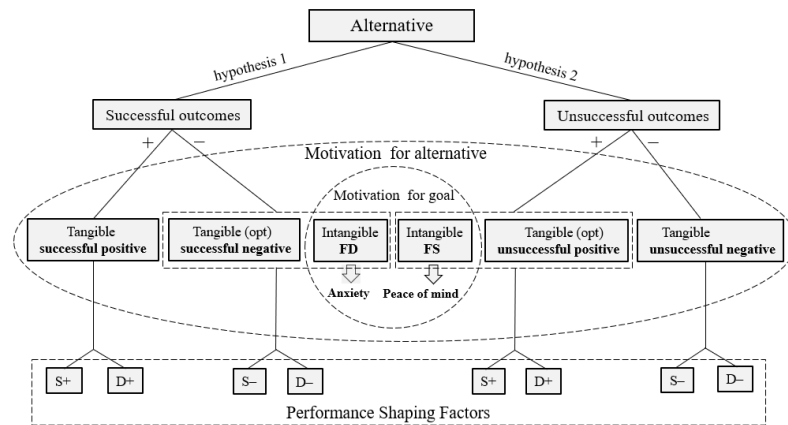
Figure 2: The level of motivation for selecting alternative as a result of evaluation of successful and unsuccessful tangible and intangible outcomes.

characterizes significance of the goal, while the factor of difficulty characterizes the difficulty of achieving this goal. It's worth noting that FS characterizes significance of the goal as a short-term goal from the perspective of achieving the long-term goal. In other words, FS is a significance of the directness of the goal towards the long-term goal. FS forms the level of positive motivation for achieving the goal and creates *peace of mind*. FD forms the level of negative motivation for achieving the goal and creates *anxiety*. In problem-solving mode (when selecting the best or most preferable alternative from available options), in order to satisfy the *principle of instrumental rationality*, each alternative's outcomes of achieving the short-term goal must be evaluated from the perspective of achieving the long-term goal. The existing uncertainty in evaluating outcomes makes the evaluation process difficult.

To reduce this uncertainty and the related difficulties, we consider two exclusive hypothetical situations: hypothesis 1, when the short-term goal (goal) is achieved (**STG**) while producing "successful" outcomes; and hypothesis 2, when the short-term goal is not achieved (¬**STG**) while producing "unsuccessful" outcomes (see Figure 2).

It is important to note that

1) If **STG**, then positive outcomes are tangible only, while negative outcomes can be tangible, intangible or both;
2) If ¬**STG**, then negative outcomes are tangible only, while positive outcomes can be tangible, intangible or both.

Figure 2 demonstrates that the level of motivation for achieving the goal is formed by FS (intangible unsuccessful positive outcome) and FD (intangible successful negative outcome).

Both FS and FD are present in any goal-directed activity and impact PSFs and the level of motivation for selecting an alternative. However, in some cases, the factor of significance can be the only unsuccessful positive outcome, and the factor of difficulty can be the only successful negative outcome.

There are three logical relations among achieving short- and long-term goals, which lead to intangible outcomes only.
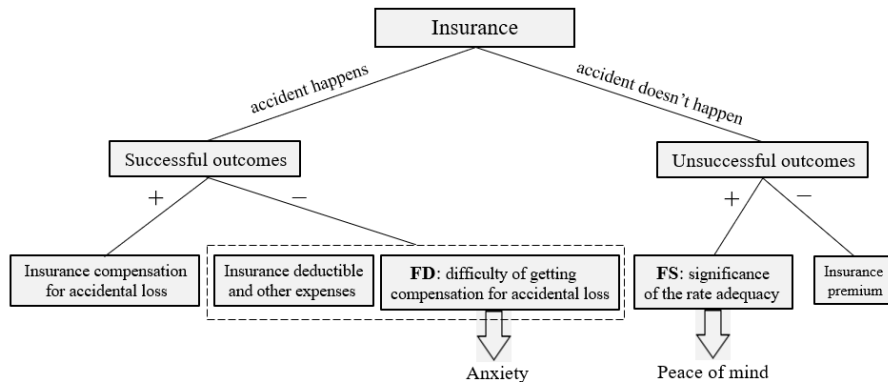
Figure 3: Factor of significance (FS) and factor of difficulty (FD) in insurance evaluation.

1) **STG** $\Rightarrow$ **LTG**: If the short-term goal is achieved (successful), then the long-term-goal is achieved.

The successful negative outcomes are intangible and presented by FD only. For example, when a patient with a high total cholesterol level decides to take statins vs adopt a healthy lifestyle, they may identify "lowering total chol < 200" as a short-term goal and "reducing risk of heart attack" as a long-term goal.

FD: *difficulty* of lowering total chol < 200, which causes *anxiety* from knowing that statins (or healthy lifestyle) may not produce the expected result of lowering total chol < 200 – patient's uncertainty regarding whether statins (healthy lifestyle) will work to help lower their total chol < 200.

2) $\neg$**STG** $\Rightarrow$ $\neg$**LTG**: If the short-term goal is not achieved (unsuccessful), then the long-term goal is not achieved.

The unsuccessful positive outcomes are intangible and presented by FS.
For example, when people try to decide about the best life, health, house, car or other insurance policies for themselves, they typically lean towards "getting financial protection in the event of accidental loss" as the short-term goal and "saving money" as the long-term goal. Their successful outcomes are associated with a hypothetical situation in which accidental loss happens, while their unsuccessful outcomes are associated with a hypothetical situation in which accidental loss doesn't happen (see Figure 3).

FS: *significance* of the rate adequacy (how insurance coverage is sufficient to cover its operating expenses and claims obligations to result in a reasonable profit when insured loss does not happen but the insurance premium must be paid).
This significance creates *peace of mind* from knowing that you have been protected. It's important to recognize that "peace of mind" becomes a tangible outcome if we consider a long-term goal more certain than simply "saving money," such as "saving money peacefully." In this case, both unsuccessful positive tangible "peace of mind" and unsuccessful positive intangible, significance of the "rate adequacy and peace of mind," will contribute to the level of motivation for choosing an alternative.

Figure 3 demonstrates that there is another intangible outcome, FD (difficulty of getting compensation for accidental loss), which causes anxiety.

Even if this negative outcome comes with a tangible "insurance deductible and other expenses," it may considerably impact the decision to select an insurance policy.

3) **(STG $\Rightarrow$ LTG) & ($\neg$STG $\Rightarrow$ $\neg$LTG)**: If the short-term goal is achieved (successful), then the long-term goal is achieved, and if the short-term goal is not achieved (unsuccessful), then the long-term goal is not achieved.

The successful negative outcomes are intangible and presented by FD and the unsuccessful positive outcomes are intangible and presented by FS. For example, when choosing among different cardiopulmonary resuscitation devices, the short-term goal may be focused on "restarting the heart and breathing," while the long-term goal may ultimately be focused on "saving a life."

FD: *difficulty* of restarting the heart and breathing, which creates *anxiety* from knowing that the cardiopulmonary resuscitation device may not produce the expected result of restarting the heart and breathing.

FS: *significance* of the class of recommendation (COR) and the level of evidence (LOE). The class of recommendation indicates the strength of recommendation, encompassing the estimated magnitude and certainty of benefit in proportion to risk.

The level of evidence rates the quality of scientific evidence supporting the intervention on the basis of the type, quality and consistency of data from clinical trials and other sources (Halperin, et al., 2016). This significance creates *peace of mind* from knowing that everything possible was done to save someone's life.

APPLICATION IN HEALTHCARE AND INSURANCE

$ED^2 StatinChoice$ and $ED^2 InsuranceChoice$ are two customized versions of *ExpressDecision2*.

$ED^2 StatinChoice$ is intended to help make a patient-centered and shared-with-clinician decision regarding taking statins for cholesterol reduction to prevent a heart attack or stroke. The two primary resources on taking statins for cholesterol reduction are The 2018 AHA/ACC Cholesterol Guideline (Grundy et al., 2019). and Mayo Clinic Statin Choice Decision-Aid tool (https://statindecisionaid.mayoclinic.org). These and other guidelines and decision aids, as well as information derived from a health professional, provide the patient with essential information regarding the pros and cons of using statins, while also empowering the patient to make the ultimate decision regarding whether they should take statins. This decision-making process is guided by tangible statistical factors regarding patient's risks of getting heart attack or stroke as well as by intangible factors, such as "peace of mind" from recognizing how statins, even despite their potential risk for side effects, will ultimately help improve patient health outcomes. It reflects subjective justification of the strength of recommendation and the level of evidence. Overall, such a problem is both uncertain and difficult for the patient and so requires them to establish both short- and long-term goals, as well as relevant options for selection. $ED^2 StatinChoice$ is designed specifically to help the patient

make the best choice in such a difficult scenario. $ED^2StatinChoice$ complements existing decision-support tools, such as the Mayo Clinic Statin Choice Decision Aid. Its method of assistance involves clarifying the goal and various choices with subsequent aggregation of all pros and cons, thus helping make a motivated decision regarding which statin therapy is most preferable.

$ED^2InsuranceChoice$ is designed to help make a client-centered and shared-with-agent decision regarding buying an insurance policy in order to reduce financial uncertainty and make accidental loss more manageable. People buy health, life, car, home and other types of insurance to protect themselves from financial loss in the event of illness, death, car damage, house fire and other accidents, respectively. For example, they make decisions when choosing from among liability, comprehensive and collision insurance types. This decision-making process is guided by tangible statistical factors regarding people's risks of accidental losses, as well as by intangible factors, such as "peace of mind" from being protected against financial loss in the event of an accident. It is important to note that peace of mind refers to a positive emotional state; it is an essential and decisive factor when selecting an insurance policy. It reflects subjective justification of rate adequacy for the premium: the premium should be reasonable and coverage must be sufficient. Unfortunately, such intangible factors as peace of mind from being protected against financial loss in an accident, as well as anxiety associated with the difficulties of obtaining compensation for accidental loss, are not sufficiently reflected in existing models of insurance choice. $ED^2InsuranceChoice$ is specifically designed to fill this gap.

CONCLUSION

In this paper, we identified two key regulators of problem-solving activity: the factor of difficulty that creates anxiety, and the factor of significance that creates peace of mind. We demonstrated how both factors that were initially intangible can be measured, and how these factors finally contribute to the level of motivation for choosing an alternative. For this, we considered hypothetical situations regarding success and unsuccess in reaching the goal as a short-term goal from the perspective of reaching the long-term goal, which allows us to clearly identify the role of intangible significance and intangible difficulty in the formation of the level of motivation. The factor of difficulty is involved as the successful negative intangible outcome, which leads to anxiety and contributes to the level of negative motivation for choosing an alternative. The factor of significance participates as an unsuccessful positive intangible outcome, which leads to peace of mind and contributes to the level of positive motivation. When it's difficult to choose the best alternative, it's recommended to reduce uncertainty of the long-term goal and make it more specific. This makes intangible outcomes more tangible from the perspective of the new long-term goal, which can produce a more accurate decision. It's important to note that intangible outcomes are present in any goal-directed activity. For example, if a successful negative intangible outcome becomes tangible, a new successful negative intangible outcome will substitute the previous one. In some cases, the factor of significance can be

the only unsuccessful positive outcome, and the factor of difficulty can be the only unsuccessful negative outcome. In this situation, anxiety and peace of mind can be the main regulators in choosing the best alternative. We gathered all our findings and input them into *ExpressDeision2*, which helps make difficult decisions under risk and uncertainty to be user-centered and shared with expert.

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