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Decision-making in domain-specific activities: estimates of dual information processing

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1. INTRODUCTION

1.1. Work relevance and scientific novelty

Decisions are being made in all fields of our life. From the practical and scientific point of view, the focus is on those domain-specific activities where the consequences of made decisions are the greatest. Emergency medicine is one those areas where the cost of a doctor's decision is extremely high – one mistake can result in the severe loss of human health or even death. According to the data of the Health Information Center of the Institute of Hygiene (2018), the number of emergency medical services provided in Lithuania during the period of 2013-2017 amounted to 225.5-239.3 per 1 000 inhabitants. 74.2-76.1. Another area is law. Judges' decisions are aimed to ensure proper application of law, in accordance with the principles of impartiality, justice, integrity and efficiency. However, mistakes made by judges can have a significant negative impact on both – individual- and societal-level. Attention is drawn to the criminal justice, because criminal law violations, nature, severity, size and legal effects of the penalties imposed are often far greater to those imposed on administrative or civil justice. According to the data of the National Courts Administration of the Republic of Lithuania (2018), the number of criminal cases analyzed on 1st Instance Courts in Lithuania during the period of 2013-2017 amounted to 17 115 to 21 674 annually. Other than decisions made in the fields of emergency medicine or criminal law, some decisions of national interest may not have objective criteria for their correctness and/or fallibility, e.g. voting in parliamentary elections. The value of voting decisions in Lithuanian parliamentary elections are high due to the low voter turnout over the last two decades (e.g., in 2004, the overall voting turnout was 46.08%, in 2008 – 48.95%, in 2012 –

52.93% and in 2016 – 50.64%) compared with other European Union countries. The situation is even worse among young (≤ 24 years old) voters with the overall voting turnout of 18.9% in 2012 and 30.5% in 2016. Decision-making research has not only practical, but also scientific relevance. It is agreed that decision-making is a result of an (reciprocal) interaction between intuitive and rational information processing (Sherman, 2009). However, research traditions of medical decision-making (namely, anesthesiologists' decision-making) and legal decision-making had not taken this into account up to now. Anesthesiologists' decision-making has only been investigated as a result of intuitive (e.g., Crowley et al., 2013; Mamede et al., 2010; Stiegler, Neelankavil, Canales, & Dhilon, 2012) or rational information processing (e.g., Joseph & Patel, 1990; O'Neill, Dluhy, & Chun, 2005; Wu, Chao Yu, Yang, & Che, 2005). The same isolation between intuitive (e.g., Englich, Mussweiler, & Strack, 2006; Mussweiler & Englich, 2005) and rational information processing (e.g., Park, 2011) is also observed in the judges' decision-making research tradition. The fundamental problem of such studies is the unclear degree of results generalization, since no studies to date have been carried out to evaluate relative contributions of intuitive and rational information processing.

This dissertation has three elements of scientific novelty. First, although the conception of dual information processing is used to theoretically explain medical (Croskerry, 2009; Croskerry & Nimmo, 2011) and legal decision-making (Guthrie, Rachlinski & Wistrich, 2007; Ronkainen, 2011), but empirical research is lacking[1]. There are at least to reasons for this: 1) the low interest of cognitive and/or experimental psychologists in the research field of domain-specific decision-making; 2) the lack of sound methods to evaluate

[1] After a thorough search on EBSCOhost databases, we did not find any scientific papers (published during 1959-2018 period), which would be aimed at measuring the contributions of doctors' or judges' dual information processing to the decision-making cycle.

dual information processing. Both types of processing are being investigated using logical tasks that do not require specific knowledge base in a particular activity (e.g., De Neys, 2006; Evans, Barston, & Pollard, 1983; Evans & Curtis-Holmes, 2005; Kahneman & Tversky, 1973). In this dissertation we present novel methodological procedure to estimate contributions of intuitive and rational information processing. For its' development we conceptually combined default-interventionist model of higher cognition (Evans & Stanovich, 2013a; 2013b; Kahneman, 2003), automaticity-dominating process dissociation procedure (Lindsay & Jacoby, 1994), and the main principles behind The Cognitive Reflection Test (Frederick, 2005; Toplak, West, & Stanovich, 2014). As a result we developed domain-specific tasks that are compatible with doctors anesthesiologists' or judges' knowledge base. We address this matter and use these tasks, respectively, in the Study 1 and Study 2. Second, for the first time in the field of social sciences in Lithuania we evaluated voters' implicit attitudes toward political parties and their representatives. Taken globally, it is relatively common practice to explore both, voters' implicit and explicit attitudes toward political parties (Bluemke & Friese, 2008; Friese, Bluemke, & Wänke, 2007; Karpinski, Steinman, & Hilton, 2005; Raccuia, 2016). However, all these studies have one important limitation: explicit and implicit attitudes are measured as directed toward political parties and/or their members in general, without specifying particular characteristics of interest. Therefore, results are very broad, in a sense that it is not possible to point out which characteristics of the parties or their members are important to voters. To the best of our knowledge, no study to date. We address this matter in the Study 3 by focusing on explicit and implicit attitudes regarding three evaluative dimensions, i.e., competence, honesty and leadership. Third, information processing is cognitive activity that is highly related with the specific domains decisions are

being made in. One of the most influential scientists in the field of information processing, whose ideas are still prevalent in contemporary cognitive psychology, Herbert A. Simon (1956), argued that the field of expertise is a fundamental criterion, which must be taken into consideration before conducting research on decision-making. Campitelli and Gobet (2010) wrote an excellent discussion on this issue regarding the specification of cognitive processes. For the first time, we estimate human dual information processing using tasks that are relevant to their knowledge base. Moreover, it is done so across three different activities. Therefore, the results of all three studies provides an opportunity to draw assumptions about whether the magnitude of relative contributions of different types of processing is universal or not across different domains.

1.2. Comparison of decision-making task characteristics in domain-specific activities

Comparison of decision-making task characteristics in three domain specific activities (emergency medicine, law and voting) is presented in Table 1. Emergency anesthesiologists are required to assess different aspects of the patient's conditions (e.g. pulse rate, blood pressure, oxygen saturation, peak airway pressure, as well as changes in these parameters, quality of intubation, patient's responses to treatment, etc.). Large number of cues encoded during the emergency medical care is often troubled by incomplete information about the subtle peculiarities of patient's condition prior to arrival. Thus, the uncertainty levels are extremely high in the emergency departments. Large number of cues and uncertainty implies a high degree of difficulty and complexity, i.e.: emergency anesthesiologists' need to make an unusually high number of (intermediate) decisions in a short period of time in order to reach a final decision. All of these

circumstances contribute to the fact that anesthesiologists experience high cognitive load and hypothetically are more prone to intuitive (heuristic) decision-making.

Table 1. Decision-making task characteristics in domain specific activities

Task characteristics	Activity		
	Emergency medicine	Law	Voting
Number of cues	Large	Large	-
Certainty level	Low	Moderate	-
Time period	Brief	Long	Long
Cognitive load	High	Moderate	Low
Complexity	High	High	Low/moderate

Before making a final judgment in any criminal case, judges are required to evaluate witnesses' testimony, the severity of the crime, the aggravating and mitigating circumstances, etc. Therefore, judges are faced with high degree of problem's difficulty and a large number of cues to be encoded. On the other hand, unlike emergency anesthesiologists, judges have an opportunity to postpone the trial controlling the time period, during which the final decision must be made. However, postponement of the trial can be curtailed by a large number of cases, high pace or monotony at work. Finally, compared with emergency anesthesiologists, judges have more information (at least a moderate amount) of the problem being solved. All of these circumstances shows that judges cognitive load can not be high.

It is difficult to pinpoint precisely the task characteristics that play role in the voting process. This is because voting choice reflects a personal opinion, which can not be objectively evaluated in terms of its' correctness and/or fallibility. Moreover, voting in political elections is optional, therefore the decision can be avoided. In turn, both emergency anesthesiologists and judges are obliged to make decisions in their field of expertise. Furthermore, there is no reliable

way to evaluate number of cues encoded by individual voter as well as available information on certain political parties. Finally, period of time (4-6 weeks), which is intended to decide on one's voting choice, is the only task characteristic that is exact. This is a fairly long period of time, therefore, it can be assumed that voters' cognitive load is low and the degree of problem's complexity is low/moderate.

1.3. Methodological rationale

1.3.1. Dual-process perspective: architecture of higher cognition

Authors of different dual-process theories agree on that the operation of human cognition is based on two types of information processing, i.e. intuitive (Type 1) and rational (Type 2 processes) (Sloman, 1996; Strack & Deutsch, 2004; Evans & Stanovich, 2013a). Recently, there have been attempts to distinguish between defining features and typical correlates of Type 1 and Type 2 processes (see Table 2).

Table 2. Typical correlates and defining features of Type 1 and Type 2 processes (Evans & Stanovich, 2013a)

Type 1 processes	**Type 2 processes**
Defining features	
Does not require working memory	Require working memory
Autonomous	Mental simulation (decoupling)
Typical correlates	
Fast	Slow
High information capacity	Limited information capacity
Parallel	Serial
Nonconscious	Conscious
Contextualized	Abstract
Associative	Rule-based
Independent of cognitive ability	Correlated with cognitive ability
Automatic	Controlled mentally

The interaction of Type 1 and Type 2 processes is usually explained following either parallel-competitive or default-interventionist model (Evans, 2007). Parallel-competitive model presuppose that dual processes operate in parallel, each having an influence on a final decision (reciprocal interaction between Type 1 and Type 2 processes only occurs if they generate different responses). However, Type 1 processes are generally faster than Type 2 processes. Moreover, it is doubtful that Type 2 processes would run every time there is a need to make a certain decision, because they require limited working memory resources. Thus, it is unlikely that human cognition would operate in a parallel-competitive fashion.

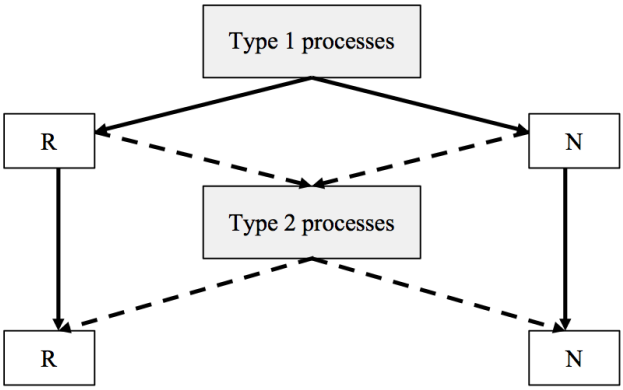

Fig. 1. Default-interventionist model of higher cognition (Evans, 2007).
Notes: R – decision to accept proposed alternative; N – decision to decline proposed alternative. Dotted line marks the intervention of Type 2 processes.

According to default-interventionist model (see Fig. 1.), information processing cycle starts with intuition (proposing **one** solution) as there is no need to waste working memory resources on every possible situation requiring a decision. Type 2 processes may

intervene only if default decision is erroneous. This architecture of human cognition is consistent with the defining features of Type 1 and Type 2 processes, i. e. Type 1 processes does not require working memory resources and can operate autonomously, whereas Type 2 processes require working memory for mental simulation (Evans & Stanovich, 2013a).

1.3.2. Process dissociation procedure

The process dissociation procedure (PDP) is a method designed by Jacoby (1991) to obtain separate quantitative estimates of contributions of intuitive and rational processes to the performance of a certain task. Originally, Jacoby (1991) developed PDP assuming the dominance of rational Type 2 processes over intuitive Type 1 processes. Later on, PDP was modified to address cases where intuitive Type 1 processes dominate rational thinking (Lindsay & Jacoby, 1994). Here we put an emphasis on automaticity-dominating PDP as it is conceptually compatible with default-interventionist model (Evans, 2007; Evans & Stanovich, 2013a; Kahneman, 2003).

Both, default-interventionist model and automaticity-dominating PDP, are hierarchical in nature and assume that Type 2 processes drive responses only if Type 1 processes fail. In order to separate the contributions of intuitive and rational processes it is essential to prepare two types of tasks (i.e. compatible and incompatible[2] with Type 1 processes). When information is being successfully processed with the help of intuitive Type 1 processes,

[2] Tasks resembling CRT items would be perfect for this. CRT (Frederick, 2005) is a psychological instrument designed to measure person's ability to override intuitive decision-making. CRT items must satisfy one essential prerequisite, i.e. intuitive responses must be incorrect, whereas correct (counter-intuitive) responses can be arrived at only after careful analysis.

correct responses will only be given on compatible items (see Fig. 2.; A). When intuitive processes fail (1 – A), information is being processed by rational Type 2 processes. There are two possible outcomes after that: 1) rational processes succeeds (C), i.e. correct responses are given on both, compatible and incompatible, items; 2) rational processes fails (1 – C), i.e. none of two items are solved correctly (Gawronski & Creighton. 2013).

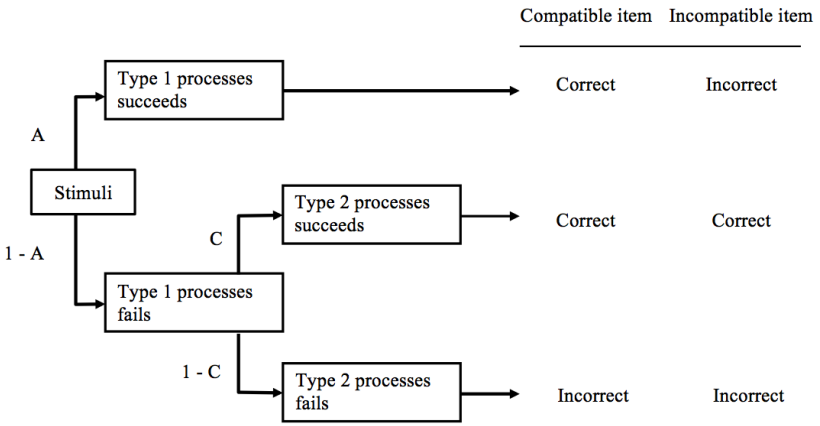

Fig. 2. Processing tree depicting automaticity-dominating PDP (Lindsay & Jacoby, 1994; Gawronski & Creighton, 2013)

Probability that correct response will be given on compatible item can be formalized: P1 = A + (1 – A) × C. Respectively, probability that correct response will be given on incompatible item can be formalized: P2 = (1 – A) × C. Therefore, contribution of intuitive Type 1 processes can be calculated: A = P1 – P2. Simply put, it is enough to calculate how many times correct response was given on compatible item **and** incorrect response was given on incompatible item. For example, if there were 56 such cases out of 70, then the relative contribution of Type 1 processes is considered high (0.8), where 0 is the minimum value, and 1 is the maximum

value. Moreover, contribution of rational Type 2 processes can be calculated: C = P2 ÷ (1 – A). Simply put, it is enough to calculate how many times correct responses were given **on both**, compatible and incompatible, items. For example, if there were 11 such cases out of 70, then the relative contribution of Type 2 processes is considered low (0.16).

* * *

Aim:

To estimate relative contributions of intuitive and rational information processing in domain-specific activities.

Tasks:

1. To estimate relative contributions of anesthesiologists' intuitive and rational information processing to the decision-making cycle solving medical vignettes of emergency medicine.
2. To estimate relative contributions of judges' intuitive and rational information processing to the decision-making cycle solving vignettes of alleged criminal cases.
3. To evaluate implicit and explicit attitudes (as indirect indicators of intuitive and rational information processing) of the 18-24 year-old electorate toward the main Lithuanian political parties, as well as attitudes' prognostic characteristics regarding the decision to vote in the Lithuanian parliamentary elections of 2016.

Statements to be defended:

1. The relative contributions of intuitive and rational information processing varies when decisions are made in different domain-specific activities.

2. When solving medical vignettes, associated with scenarios in the fields of orthopedics and traumatology, anesthesiologists rely more on intuitive, compared with rational information processing.
3. When solving vignettes of alleged robbery crimes, judges rely more on rational, compared with intuitive information processing.
4. 18-24 year-old electorate is more likely to rely on explicit attitudes rather than implicit attitudes when deciding to vote for the Liberal Movement or Homeland Union – Lithuanian Christian Democrats. Indirectly it indicates that 18-24 year-old electorate is more likely to rely on rational rather than intuitive information processing.

2. STUDY 1

2.1. Methods

2.1.1. Participants

84 anesthesiologists and anesthesiology residents participated in this study (M_{age} = 28.19, SD_{age} = 2.49; $M_{experience}$ = 3.42, $SD_{experience}$ = 1.14) practicing and working in Vilnius University Hospital Santaros Klinikos or The Hospital of Lithuanian University of Health Sciences Kauno klinikos.

Participants were randomly assigned to one of the two conditions. Half of the participants were asked to make decisions intuitively under time pressure (M_{age} = 28.52, SD_{age} = 3.05; $M_{experience}$ = 3.52, $SD_{experience}$ = 1.17) – *intuitive condition group*; another half of the participants were asked to make decisions rationally without time restrictions (M_{age} = 27.95, SD_{age} = 1.74; $M_{experience}$ = 3.36, $SD_{experience}$ = 1.12) – *rational condition group*.

2.1.2. Medical vignettes

Process dissociation procedure. Before the beginning of item development, we set three criteria that had to be met in order for medical vignettes to be compatible with automaticity-dominating process dissociation procedure:

1. Medical vignette that is compatible with intuitive information processing (i.e. target item) must elicit only one obvious and correct response. It is reached regardless of the manner (intuitively or rationally) participants are asked to make decisions.
2. Medical vignette that is incompatible with intuitive information processing (i.e. dummy item) must elicit several different responses. It is more likely that incorrect response will be given

by participants who are asked to make decision rationally without time restrictions. Respectively, it is more likely that correct response will be given by participants who are asked to make decision intuitively under time pressure.

3. Both, target and dummy, items must elicit the same response for participants, who are asked to make decision intuitively under time pressure. (Note: the response is correct on dummy item, but incorrect on target item).

Vignettes' content. After deciding on these three criteria, we started item development. Unlike classical CRT, which is based on logical problems, the creation of domain-specific CRT items requires one to have an extensive knowledge in the certain field. Therefore, the validation of domain-specific CRT items must involve experts. We conducted semi-structured interviews (approximate duration of one interview – 30-40 minutes) with seven anesthesiologists (M_{age} = 30.14, $M_{experience}$ = 5.14) to collect information about the frequency and difficulty of various intraoperative medical care situations that occur in the emergency departments. During the interview participants were asked:

1) to identify difficulties and complications they *usually* encounter in the emergency departments;
2) to describe in a great detail at least one situation when those difficulties or complications manifested;
3) to name other less frequently emerging conditions in the emergency departments.

Six out of seven anesthesiologists recalled examples of **bleeding** as a complication that usually occur in emergency departments during intraoperative medical care. According to the literature, bleeding is very common perioperative complication (Kauvar & Wade, 2005). Respondents also recalled atypical condition such as **fat embolism**. Epidemiological studies support these results. The incidence rate of fat embolism is fairly rare

condition with the incidence rate of .15%-2.6% in trauma patients (Bulger, Smith, Maier, & Jurkovich, 1997; Stein, Yaekoub, Matta, & Kleerekoper, 2008; Tsai et al., 2010). Moreover, respondents mentioned that fat embolism may actually be interpreted as bleeding provided that the information about the patients' status is unclear or presented in a chaotic way. According to the interview results one dummy and one domain-specific target CRT item (see full dissertation for textual descriptions of both vignettes) were created with the help of three experts with 10 years of experience in anesthesiology. The latter item was created to make an impression that the patient is bleeding, even though the real threat is fat embolism.

Both of the complications are covered in the curricula of the first two years of residency. Therefore, we expect the number of faulty answers resulting from the lack of knowledge from the part of participant to be minimal.

Structure[3]. The beginning and the middle part of both vignettes consists of contextual information that is not sufficient to make a definite decision. Pivotal information (in bold) that is necessary and sufficient to come up with the final decision is presented only at the very end. This kind of structure was selected to rule out or minimize the activation of rational reasoning when one is asked to make decision intuitively. Vignettes were created in a video format (doi:10.5281/zenodo.897623) with the duration range of 3 minutes and 15-36 seconds. The content of specific situation matched the visual background where appropriate actions were made by two surgeons and two anesthesiologists.

[3] See full dissertation for more details.

2.1.3. Procedure

Vignettes were randomized and individually presented to participants using the computer screen one by one. *Intuitive* and *rational groups* received different information about the purpose of this study as well as different instructions on how to proceed with the upcoming problem solving. Schroyens and colleagues' (2003) study showed that particular instructions on the speed of decision-making in fact triggers intuitive / rational decision-making. Intuitive group was told that the purpose of the current study is to determine what kind of thoughts ***pops-up automatically*** to the anesthesiology specialists when they are faced with difficult emergency situations in operative room. Instruction to solve medical vignettes to this group was:

"*After the review of every medical vignette you will have to give your answer, preferably the first thought that comes to your mind, as fast as you possibly can. We will measure the speed of your answers.*"

Rational group was told that the purpose of the current study is to determine the correctness of the answers which anesthesiology specialists provide confronted with difficult emergency situations in operative room. Instruction to solve medical vignettes to this group was:

"*After the review of every medical vignette you will have to give an answer you think is correct. There will be no time restrictions, therefore you will have an unlimited amount of time to make your decision. Please think carefully.*"

2.1.4. Data analysis

Preliminary data analysis. Before conducting main data analysis, we had to examine whether target vignette meet requirements specific to CRT items, i.e. whether correct responses are given in rational processing condition, and incorrect responses – in intuitive processing condition. Vignette's suitability could only be confirmed, if both hypotheses presented below were true:

Hypothesis 1: there is no significant difference between intuitive and rational groups' performance on dummy vignette.

Hypothesis 2: intuitive group's performance on target vignette is significantly worse compared with that of rational group.

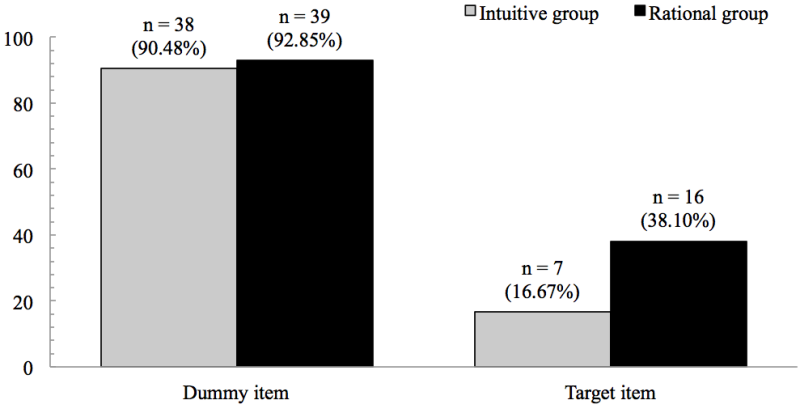

Fig. 3. Number and percentage of correct responses on dummy and target vignettes within both groups

Number and percentage of correct responses on dummy and target vignettes within both groups are presented in Fig. 3. High percentage of correct responses on dummy *bleeding* vignette indicate that, practically, it elicited only one response. χ^2 test of homogeneity

showed that there was no statistically significant difference (*Fisher's exact test*, p = .99) between two groups' performance on dummy vignette. Fairly low percentage of correct responses on target *fat embolism* vignette indicate that, as expected, it elicited several different responses. χ^2 test of homogeneity showed that intuitive group's performance on target vignette was significantly worse (*Pearson* $\chi^2 = 4.85$, $p < .05$) compared with that of rational group. Summing up all these results it can be concluded that the pair of vignettes meets requirements specific to CRT items and can be used as a part of process dissociation procedure.

Main data analysis. The contribution of anesthesiologists' Type 1 processes to the decision-making cycle was evaluated separately for *intuitive* and *rational condition group*. This was done by counting the number of participants who gave correct response on compatible item **and** incorrect response on incompatible item. The contribution of anesthesiologists' Type 2 processes was also evaluated separately for each experimental group. This was done by vaunting the number of participants who gave correct responses **on both**, compatible and incompatible, items.

2.2. Results and discussion

Estimates of Type 1 and Type 2 processes during a decision-making cycle are presented in Fig. 4. Within-group analysis showed that contribution of anesthesiologists' Type 1 processes, compared with Type 2 processes, was significantly higher (see # in Fig. 4.) in intuitive condition group. However, in rational condition group, the contribution of anesthesiologists' Type 1 and Type 2 processes were equal (# #). Between-group analysis showed no statistical significant differences between the contributions of anesthesiologists' Type 1 processes (*), both of which appeared to be at moderate/high levels. Similarly, there was no statistical significant differences between the

contributions of anesthesiologists' Type 2 processes (**), both of which appeared to be at low/moderate levels.

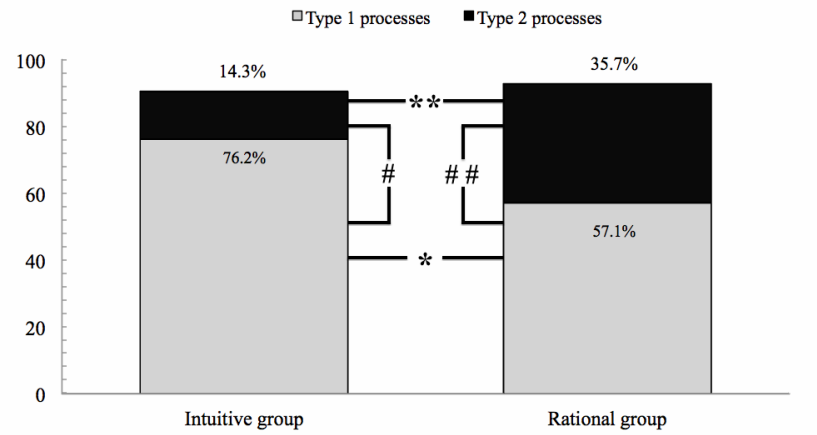

Fig. 4. Estimates of Type 1 and Type 2 processes during a decision-making cycle.

*Notes: * – $\chi^2 = 3.429$, $p = .065$ (Bonferroni correction: $\alpha = .0125$);*
*** – $\chi^2 = 5.143$, $p = .023$ (Bonferroni correction: $\alpha = .0125$);*
 # – McNemar $\chi^2 = 17.789$, $p < .001$ (Bonferroni correction: $\alpha = .0167$);
– McNemar $\chi^2 = 2.076$, $p = .149$ (Bonferroni correction: $\alpha = .0167$).

It should be noted that there were no statistically significant difference on accuracy of made decisions between two groups (U = 724.5, Z = -1.405, p = .16). There were no statistically significant associations between the estimates of Type 1 / Type 2 processing and participants' age (r = .07, p = .535) or clinical experience (r = .11, p = .338).

Study 1 addresses three important aspects and gaps in the existing literature on cognitive processing in general and medical decision-making in particular. First, it was found that anesthesiologists' intuitive information processing predominates rational information processing when decisions are made under time

pressure. It is not surprising given that environment of emergency departments can be best characterized as intuition-inducing, e.g.: time to make decisions is limited, information regarding patient's health status is usually incomplete, cues are displayed simultaneously, etc. Interestingly, there was no predominance of either type of information processing in rational condition when decisions were made without time constrains. One of the likely explanations to this relies on the process of information automatization (Croskerry, 2009). Even when there is time to employ meta-cognition resources, some of the medical cases may be still processed with the help of the Type 1 processes, due to frequent repetition in the past. This assumption can be best tested with longitudinal design study, where the estimates of intuitive and rational information processing would be measured for the same participants across different periods of time. Second, despite different patterns of intuitive and rational information processing contribution to decision-making regarding both experimental conditions, there was no difference in accuracy of made decisions between the groups. These findings suggest that intuition alone may be as effective as, or even more effective than a mix of equivalent combination of intuition and rationality while shaping anesthesiologists' information processing. In a light of these results, an increased attention to the research regarding phenomena of intuitive information processing (such as heuristics and biases) seems well justified in a field of emergency medicine (Aberegg, Haponik, & Terry, 2005; Maceina et al., 2016; Mamede et al., 2010; Marewski & Gigerenzer, 2010). What all these studies have in common is their disregard to rational information processing while concentrating only on intuitive side of decision-making. According to the results of current research, previous studies would only account to three-quarters (.762) of information processing. Moreover, results of our study suggests that about one eighth (.143)

of information processing in the context of emergency medical care is still under the govern of rationality. Therefore, as small as it is, rational information processing is not accounted for in any of the previously mentioned studies. We are aware that results of our study are preliminary and in a need to be replicated with the broader spectrum of scenarios with as diverse content as possible. Third, results of the Study 1 showed that there were no associations between the use of intuitive / rational information processing and anesthesiologists' age or clinical experience. In a context of heuristics and biases research, these results may be interpreted as showing relatively stable contribution of intuitive information processing to decision-making.

3. STUDY 2

3.1. Methods

3.1.1. Participants

98 judges (32.65% males, 67.35% females) participated in this study (M_{age} = 46.05, SD_{age} = 10.09; $M_{experience}$ = 12.44, $SD_{experience}$ = 8.06) working various courts of general jurisdiction of Lithuania.

Participants were randomly assigned to one of the two conditions. 51 participant was asked to make decisions intuitively under time pressure (M_{age} = 44.58, SD_{age} = 10.09; $M_{experience}$ = 11.83, $SD_{experience}$ = 8.00) – *intuitive condition group*. 47 participants were asked to make decisions rationally without time restrictions (M_{age} = 47.81, SD_{age} = 8.89; $M_{experience}$ = 13.15, $SD_{experience}$ = 8.15) – *rational condition group*.

3.1.2. Vignettes of alleged robbery crimes

Process dissociation procedure. Vignettes of alleged robbery crimes for this study were developed and prepared under the same rationale as in Study 1 (see full dissertation for more detailed explanation).

Structure. Vignettes of alleged robbery crimes were prepared in the form of text. The average reading time of one vignette is about 2 minutes and 20 seconds. Each vignette starts with the delineation of defendants' demographic information, history of previous conviction and the reference to article of The Criminal Code of the Republic of Lithuanian based on which charges are brought. The circumstances of the alleged crime, the legal assessment of the crime, defendants; behavior on court, etc., are presented in the middle of each vignette. Finally, a brief scenario with either misleading (does not comply with the article on which charges are being brought), or

correct anchor (complies with the article on which charges are being brought) is presented in order to differentiate between *target* and *dummy* item (see full dissertation for more detailed information about vignettes).

3.1.3. Procedure

The main principles of the procedure are the same as in the Study 1, outlined in chapter 2.1.3. (see full dissertation for more details).

3.1.4. Data analysis

Preliminary data analysis. Number and percentage of correct responses on dummy and target vignettes within both groups are presented in Fig. 5.

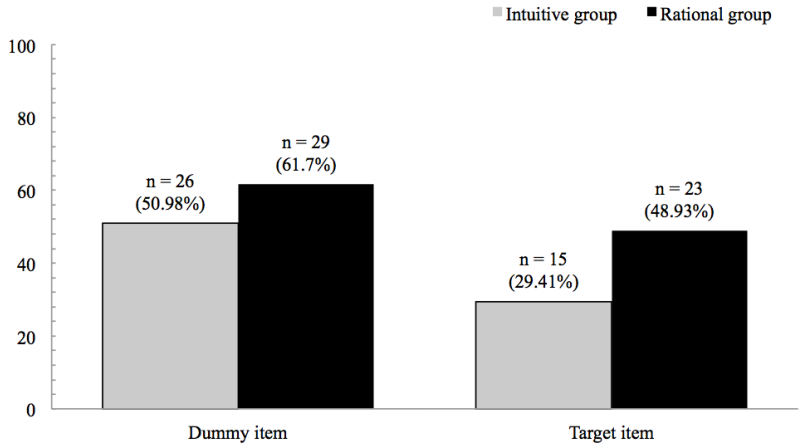

Fig. 5. Number and percentage of correct responses on dummy and target vignettes within both groups

Before conducting main data analysis, we had to examine whether target vignette meet requirements specific to CRT items, i.e. whether correct responses are given in rational processing condition, and incorrect responses – in intuitive processing condition. χ^2 test of homogeneity showed that there was no statistically significant difference (*Pearson* $\chi^2 = 1.59$, $p = .99$) between two groups' performance on dummy vignette. Moreover, χ^2 test of homogeneity showed that intuitive group's performance on target vignette was significantly worse (*Pearson* $\chi^2 = 3.927$, $p < .05$), compared with that of rational group. Summing up all these results it can be concluded that the pair of vignettes meets requirements specific to CRT items and can be used as a part of process dissociation procedure.

Main data analysis. The contribution of judges' Type 1 processes and Type 2 processes to the decision-making cycle was evaluated separately for *intuitive* and *rational condition group* using the same rationale as in Study 1.

3.2. Results and discussion

Estimates of Type 1 and Type 2 processes during a decision-making cycle are presented in Fig. 6. Within-group analysis showed that there was no statistically significant difference between contributions of judges' Type 1 and Type 2 processes (see # in Fig. 6.) in intuitive condition group. However, in rational condition group, the contribution of judges' Type 1 process was statistically significantly lower, compared with the contribution of Type 2 processes (# #). Between-group analysis showed no statistical significant differences between the contributions of judges' Type 1 processes (*), both of which appeared to be at low levels. Similarly, there was no statistical significant differences between the contributions of judges' Type 2 processes (**), both of which appeared to be at moderate levels.

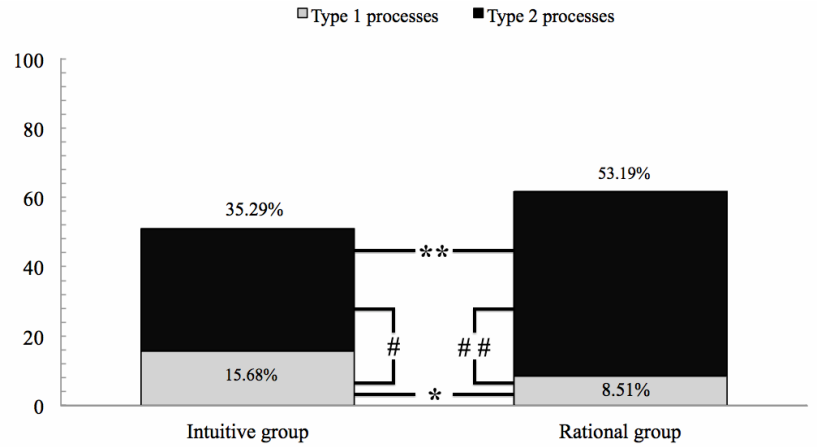

Fig. 6. Estimates of Type 1 and Type 2 processes during a decision-making cycle.

*Notes: * – χ^2 = 1.172, p = .065 (Bonferroni correction: α = .0125);*
*** – χ^2 = 3.182, p = .074 (Bonferroni correction: α = .0125);*
 # – McNemar χ^2 = 3.846, p = .049 (Bonferroni correction: α = .0167);
 # # – McNemar χ^2 = 15.206, p < .001 (Bonferroni correction: α = .0167).

It should be noted that there were no statistically significant difference on accuracy of made decisions between two groups (U = 989.5, Z = -1.482, p = .14). There were no statistically significant associations between the estimates of Type 1 / Type 2 processing and participants' age (r = .01, p = .933) or experience (r = .05, p = .705).

Study 2 addresses the three aspects and gaps in the existing literature on cognitive processing in general and legal decision-making in particular. First, results showed that judges' rational information processing predominates intuitive information processing when decisions are made without time constrains. It is not surprising given the characteristics of court environment and legal cases in general. Judges are faced with high degree of problem's difficulty: before making a final judgment in any criminal case, judges ought to evaluate witnesses' testimony, the severity of the

crime, the aggravating and mitigating circumstances, etc. Moreover, unlike emergency anesthesiologists, judges have an opportunity to postpone the trial. Altogether it shows that judges cognitive load can not be high therefore it is only natural for judges to rely on rational information processing. Interestingly, judges also were more likely to rely on rational information processing (35.29%), compared with intuitive information processing (15.68%) when decisions were made. There is no paradox. The logical explanation can be found considering hybrid model of dual information processing (De Neys, 2012; 2014; Bago & De Neys, 2017). It is very likely that judges were able to make correct decisions on target times under conditions inducing intuitive information processing due to their ability to simultaneously activate **two or more** alternative solutions, one of which is based on adequate mental schemata. This interpretation can be also reinforced by the fact that judges in intuitive condition group had fairly high experience in their field (M = 11.83, SD = 8.00). Such period of time is more than sufficient to build adequate knowledge base that incorporates correct solution to various legal cases. Second, despite slightly different patterns of intuitive and rational information processing contribution to decision-making regarding both experimental conditions, there was no difference in accuracy of made decisions between the groups under time pressure. These findings suggest that rational information processing alone may be as effective as, or even more effective than a mix of equivalent combination of intuition and rationality while shaping judges' information processing. Third, results of the Study 2 showed that there were no associations between the use of intuitive / rational information processing and judges' age or clinical experience. In a context of heuristics and biases research, these results are in agreement with other empirical data (Englich, Mussweiler, & Strack, 2005; 2006) and may be interpreted as showing relatively stable contribution of intuitive information processing to decision-making.

4. STUDY 3

4.1. Methods

4.1.1. Participants

During the period from 16 September 2016 to 8 October 2016, 91 (23.6% males, 76.4% females) students of Vilnius University participated in this study (M = 20.9 years, SD = 2.22). It is important to note that sample is biased toward an educated, urban electorate. This bias seems to be inevitable, because according to The Lithuanian Department of Statistics, over 90% of young (from 18 to 24 years old) adults are educated (i.e., have acquired secondary or higher education). This social group, among young adults, usually favors right-wing parties, e.g., the Liberal Movement or the Homeland Union – Lithuanian Christian Democrats. Therefore, we expect the sample to be biased toward these political parties as well.

4.1.2. Materials and procedure

Participants were asked to evaluate six major Lithuanian political parties[4] concerning their *competence*, *honesty* and *leadership* on a 7-point scale ranging from "1 = poor fit" to "7 = excellent fit," which measured their explicit attitudes toward the political parties across these three evaluative dimensions (see full dissertation for the questionnaire). After this task, participants completed three sets (one set for one evaluative dimension) of six Single-Target Implicit Association Tests (ST-IATs) (Wigboldus, Holland, & van

[4] 14 candidate political parties participated in the Lithuanian parliamentary elections of 2016. According to the results of the Lithuanian parliamentary elections from 2012 and the ratings of the second half of the year 2016, only six political parties exceeded the 5% limit of the total votes cast to be eligible for a seat.

Knippenberg, 2006). See Table 3 for an example of one set of six consecutive ST-IATs.

In each ST-IAT set participants started with a practice block of 12 trials, in which they had to discriminate between positive and negative words (e.g., in a set of ST-IATs measuring implicit attitudes toward the political parties' leadership, words were associated with positive and negative leader attributes). Training trials are intended to make sure that participants clearly understand and are able to discriminate words with different valence. Afterward, participants completed one block of 30 trials in which positive attributes and stimuli representing target political party were assigned to the left-key (i.e. "E") and negative attributes to the right key (i.e., "I"). In the third block, this combination was reversed. It is known that stimuli categorization becomes faster and more accurate when one and the same key is pressed by grouping two cognitively closely related phenomena. Thus, a faster and more accurate categorization of stimuli in the second/third block respectively show positive/negative attitudes toward the target political party. Procedure was repeated with all six political parties summing up to 13 blocks in total. Both evaluative categories were represented by six words (see full dissertation for the list of all evaluative words used in ST-IATs), while political parties were represented by two pictures[5] (party emblem and the picture of the chairman) and one text stimuli (name of first vice chairman / chairwoman) (see full dissertation for pictorial and text stimuli representing political parties). Each stimulus was presented at least three times, adding up to 30 trials per one block. Target stimuli, coupled and uncoupled evaluative stimuli occurred in a ratio of 9:9:12 trials, leading to a proportion of left-hand and right-hand responses of 4:3 in one and 3:4 in the other combined block.

[5] Note: identical pictures of political parties' emblems and chairmen were used as stimuli in the questionnaire and all ST-IATs.

Table 3. Category assignment and stimulus proportions across blocks on one set of six consecutive ST-IATs

Task description	Left-key response	Right-key response	Number of trials		
			Pos.	Neg.	P.
1. Training blk.	Pos. words	Neg. words	6	6	-
2. Initial blk.	Pos.; LSDP	Neg.	9	12	9
3. Reversed blk.	Pos.	Neg.; LSPD	12	9	9
4. Initial blk.	Pos.; TS-LKD	Neg.	9	12	9
5. Reversed blk.	Pos.	Neg.; TS-LKD	12	9	9
6. Initial blk.	Pos.; TT	Neg.	9	12	9
7. Reversed blk.	Pos.	Neg.; TT	12	9	9
8. Initial blk.	Pos.; LVZS	Neg.	9	12	9
9. Reversed blk.	Pos.	Neg.; LVZS	12	9	9
10. Initial blk.	Pos.; LRLS	Neg.	9	12	9
11. Reversed blk.	Pos.	Neg.; LRLS	12	9	9
12. Initial blk.	Pos. + DP	Neg.	9	12	9
13. Reversed blk.	Pos.	Neg. + DP	12	9	9

Abbreviations: LSDP – the Social Democratic Party of Lithuania, TS-LKD – the Homeland Union – Lithuanian Christian Democrats, TT – Order and Justice, LVZS – the Lithuanian Farmers and Greens Union, LRLS – the Liberal Movement, DP – the Labor Party, Pos. – positive stimulus, Neg. – negative stimulus, P. – stimulus representing political parties, blk. – block.

ST-IATs were administered with *Inquisit 5 Lab* software. Each of the three ST-IAT sets as well as six consecutive ST-IATs in one set were presented in individually randomized order.

Finally, participants were asked to answer a question "*Whom will you vote for in the Lithuanian parliamentary elections on 9 October 2016?*", which measured voting intention. After the parliamentary elections we contacted all participants and got information about their actual vote choice. Study was carried out in a laboratory in groups of five-seven participants at a time. Overall, participation in a study took about 40 minutes.

4.1.3. Data analysis

Data on explicit attitudes were standardized by calculating z-scores. Data acquired from the ST-IATs were prepared as follows. First of all, to calculate the ST-IAT d-scores, we used an improved scoring algorithm with a built-in error penalty (Greenwald, Nosek, & Banaji, 2003). Trials with response latencies below 300 milliseconds and above 5000 milliseconds were discarded from further analysis. It should also be noted that two participants who had made 20% or more errors in at least one of 12 combined blocks on any set of ST-IAT were omitted. The resulting d-score ranges from -2 to 2, providing information about the direction and strength of the implicit attitude toward political parties across a certain evaluative dimension.

4.2. Results and discussion

It was found that voters' explicit attitudes toward target political parties (LRLS and the TS-LKD) predict their voting choice better, compared with implicit attitudes. It is evidenced by the following four blocks of statistical data. First, implicit attitudes no longer predicted (or did not predict) voters' decision to vote for LRLS and TS-LKD when included into the multinomial logistic regression models together with explicit attitudes (joint model). Second, the percentage of cases correctly classified (%CCC) of joint models reduced or remained the same, compared with/to the models that include only the explicit attitudes. Third, ROC analysis showed that explicit attitudes had a larger sensitivity and specificity (AUC = .73) classifying the electorate of target parties, compared with implicit attitudes (AUC = .682-.664)[6]. Fourth, even in cases where implicit

[6] *Note:* AUC of .7-.79 values indicates a sufficient degree of classification; .8-.89 – good classification ; ≥ 0.9 – excellent classification

attitudes (included in multinomial logistic regression models individually) predicted decision to vote for LRLS and TS-LKD, pseudo R^2 (Nagelkerke R^2 = .083-.099; Cox-Snell R^2 = .073-.086) were more than twice lower, compared with those of joint models (Nagelkerke R^2 = .218-.224; Cox-Snell R^2 = .191-.194) or models where explicit attitudes were taken individually (Nagelkerke R^2 = .186-.205; Cox-Snell R^2 = .163-.178). It must be added that the last argument is the weakest one and should be interpreted with caution, since pseudo R^2 in logistic regression, in contrast to the R^2 in linear regression, do not summarize the proportion of variance in the dependent variable associated with the predictor variable (Cox & Snell, 1989; McFadden, 1974; Nagelkerke, 1991).

To sum up, the combination of these results suggests that voters' decisions to vote either for LRLS or TS-LKD were driven more by Type 2 processes, compared with the Type 1 processes. This is because empirical studies suggest that implicit attitudes are formed through associative learning, intuitively whereas explicit attitudes are formed through rule-based, propositional learning with the help of rational information processing (Gawronski & Bodenhausen, 2006; McConnell & Rydell, 2014; Rydell & McConnell, 2006; Rydell, McConnell, Mackie, & Strain, 2006; Smith & DeCoster, 2000).

(Hosmer & Lemeshow, 2000). In the context of applied psychology and other social sciences, a good or excellent degree of classification is lower, i.e.: .7-.75 (Rice & Harris, 2005).

5. GENERAL DISCUSSION

Taking results of all three studies into account in can be concluded that relative contributions of Type 1 / Type 2 processing varies when decisions are made in different domain-specific activities using a specific knowledge base. This means that the operation of dual information processing is by no means universal as depends on: 1) the content of information being processed; 2) the circumstances under which the specific knowledge is accumulated and; 3) the circumstances under which the knowledge base is applied.

5.1. Practical recommendations

It was found that anesthesiologists rely more on intuitive, compared with rational information processing. In order to reduce bias that stem from suboptimal intuitive decision-making it is meaningful to take measures to improve the effectiveness of intuitive information processing. One way of doing that is educational training focused on learning different information processing strategies that reduce cognitive errors (Croskerry, 2003; Croskerry, Singhal, & Mamede, 2013; Milkman, Chugh, & Bazerman, 2009; Soll, Milkman, & Payne, 2014). To the best of our knowledge, no form of cognitive training is a part of undergraduate or post-graduate medical programs in anesthesiology in Lithuanian universities. Therefore, based on the guidelines provided by Croskerry (2003), Soll and colleagues (2014) we suggest to implement such cognitive training course covering the following topics: 1) "The origins of bias: intuitive and rational information processing"; 2) Heuristics and cognitive errors; 3) "Metacognition"; 4) "Cognitive forcing strategies that reduce bias".

Despite the results of Study 2 (which showed that judges rely more on rational, compared with intuitive information processing), we do not exclude the possibility that a similar training course could

also be useful for judges. This is because metacognition can be applied more effectively on courts of law, compared with emergency departments, since judges have a much longer time to make their final judgments.

Finally, findings of Study 3 suggest that 18-24 year-old electorate is more likely to rely on rational, compared with intuitive information processing, during their voting decision. These results cast doubt on political campaigns that are focused on short-term impression making (e.g.: elective slogans, billboard advertising or leaflets), as these measures induce intuitive, rather than rational information processing. In contrast, political parties and candidate are recommended to organize more events that stimulate rational information processing (e.g. discussions or conferences on key political issues and thorough introduction to different programs of various political parties).

5.2. Limitations

Broader generalizations about the subject under discussion require a larger database of vignettes, both in the field of anesthesiology and law. Moreover, participants' age and/or experience in the field were quite different. On the one hand, it complicates the comparison of the results across all three studies. On the other hand, empirical research on medical decision-making in anesthesiology (Maceina et al., 2016) and legal decision-making (Englich et al., 2005; 2006) show that intuitive information processes (namely, the use of heuristics) is not related with professional experience. This phenomenon is also evident in our Study 1 and Study 2. Nevertheless, for further research we recommend to recruit participants of similar age and/or professional experience across different groups, or at least to take into account learning curves in domain-specific activities.

CONCLUSIONS

1. The relative contributions of Type 1 / Type 2 processing varies when decisions are made in different domain-specific activities.
2. When solving medical vignettes, associated with scenarios in the fields of orthopedics and traumatology, anesthesiologists rely more on intuitive, compared with rational information processing.
    2.1. The contributions of anesthesiologists' Type 1 processes is equal to 76.2% and Type 2 processes – to 14.3% in the intuitive condition groups;
    2.2. The contributions of anesthesiologists' Type 1 processes is equal to 57.1%, and Type 2 processes – to 35.7% in the rational condition group.
3. When solving vignettes of alleged robbery crimes, judges rely more on rational, compared with intuitive information processing.
    3.1. The contributions of judges' Type 1 processes is equal to 15.68% and Type 2 processes – to 35.29% in the intuitive condition group;
    3.2. The contributions of judges' Type 1 processes is equal to 8.51% and Type 2 processes – 53.19% in the rational condition group.
4. 18-24 year-old electorate is more likely to rely on explicit attitudes rather than implicit attitudes when deciding to vote for the Liberal Movement or Homeland Union – Lithuanian Christian Democrats. Indirectly it indicates that 18-24 year-old electorate is more likely to rely on Type 2 rather than Type 1 processing.

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