Undecided? A board game about intertemporal choices in software projects

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Abstract
Software projects teem with choices that have a temporal component – i.e. they involve uncertain future outcomes that are spread in time. In the field of Judgment and Decision Making, such decisions are called "Intertemporal Choice" situations. The board game "Undecided?" simulates a software project through a series of intertemporal choices made by a team decision. It is designed to be educational and fun, but its aim is to provide a platform for cognitive and social studies of decision making in software projects. This paper describes the game and outlines possible research designs.

1. Overview
Software projects teem with choices that have a temporal component – i.e. they involve uncertain future outcomes that are spread in time. In the field of Judgment and Decision Making, which draws on psychology, behavioural economics, neuroscience and other fields, such decisions are called "Intertemporal Choice" situations. In software projects, such choices surface in many areas including technical debt management, iteration planning, personnel development, requirements prioritization, test automation, refactoring, code documentation, and many other issues (Becker et al., 2018, 2017). The temporal distance at which various outcomes occur in such situations has a marked effect on how they are perceived, considered, evaluated, judged, and selected. But even within Judgment and Decision Making, there is no one robust theory about how exactly people really make up their mind in these situations – neither on the individual nor on the group level. We have performed initial behavioral studies to establish the relevance of intertemporal choice in technical debt decisions (Becker et al., 2019; Fagerholm et al., 2019), but these studies have not yet examined just how professionals make their judgment.

The board game "Undecided?" simulates a software project through a series of choices made by a team decision. In each round, the team makes a choice on a next "move" by selecting from a number of cards at their disposal. Each move has uncertain effects in four dimensions (internal quality, external quality, process, and team), some of which are spread in time. At periodic intervals, the team is faced with challenges – meeting thresholds for each dimension; handling unforeseen events; justifying their choices. The game is designed to be fun and educational – we anticipate it being played as part of a moderated workshop and used for a debriefing discussion. But it is also designed to be a platform we can use to study how teams consider the temporal aspects of their choices. The game materials will be made available at cost to anyone interested. An app for hybrid and online play is in development.

In this contribution, we present the game design and outline possible research designs. At PPIG, we organized a gameplay and discussion mini-workshop on multiple boards. Gameplay takes about 60-90 minutes. We then debriefed with the participants; provided a bit more context on the intertemporal nature of decisions and our initial ideas for study designs; and finally, discussed possible applications, extensions, educational applications, and study designs. Below, we introduce key concepts of intertemporal choice, describe the game design, and outline possible research designs for studies using the game to examine how people make intertemporal choices.

2. Intertemporal choices in programming, software engineering, and systems design
"Intertemporal choice" (Loewenstein et al., 2003) is the technical term psychology and adjacent disciplines – behavioural economics, neuropsychology, neuroeconomics (Loewenstein et al., 2008) and other disciplines studying Judgment and Decision Making (*The Wiley-Blackwell handbook of judgment and decision making*, 2015) – give to decisions between uncertain outcomes that are distributed across time. The choices may or may not be explicitly listed and distinguished; and their probability may be clear or less clear. In contrast to the common probabilistic connotation of *uncertainty*, the term

ambiguity describes situations where probabilities themselves are not certain (Camerer & Weber, 1992; March, 1978).

A few examples of software project choices that feature a strong intertemporal component are:

- *Upgrading the software development toolchain* is an effort to improve team and process performance in the medium to long run, but the immediate outcome is missed productivity over the short term, as the team spends time on building infrastructure instead of 'billable hours'.
- *Test automation* is similarly an effort in improving the infrastructure used to develop, test and deploy software that does not immediately result in features or improved quality.
- *Professional development* of team members or the whole team has no direct impact on the software system under development, but it is certainly intended to have longer-term and far-reaching benefits for everyone involved.

In each of these examples, the delayed effect is assumed to be positive, while the immediate effect is generally seen as a cost to those making management-level decisions. (Whether that is appropriate is a different question, because it may ignore the innate value of such activities as education!) In other situations, the delayed effect is negative.

- *Bugfixing* under time pressure will often involve a choice between a quick solution that runs the risk of introducing technical debt and a thorough approach that carries a higher momentary cost in relation to the single bug, but introduces less technical debt to carry forward.

From the beginning of the software engineering discipline, there have been lamentations about the lack of long-term perspective (Becker, 2014; Naur & Randell, 1969; Neumann, 2012; Parnas, 1994); but the insights from psychology on this very subject have not been actively deployed. For example, the change of valuation of positive effects across time seems to differ from the change that negative effects undergo when they are pushed into the distance, with very interesting effects on so-called 'mixed outcomes' (Soman et al., 2005).

The classical, normative view of intertemporal choice takes a rationalistic stance: A discount rate is used to model the difference that time *should* make in the evaluation of possible outcomes from the perspective of an idealized agent. This results in a function that computes a value for an outcome depending on its distance in time. The classic model of discounted utility by Samuelson uses an exponential curve (Samuelson, 1937). Empirical results have often suggested that a hyperbolic curve is a better fit for human behaviour (Frederick et al., 2002). There are however significant arguments against the use of both, summarized in (Fagerholm et al., 2019). In addition, one prominent study (Zauberman et al., 2009) suggested that the concept of mathematical discount functions is entirely misguided, since the human brain does not process time in this way – instead, this study demonstrated that instead of *discounting* future events, the participants *perceived* events in time proportionally to their distance from the present. *Perception*, rather than the discounting of the future, was the explanatory model proposed and empirically validated

On a broader level, dissatisfaction with the 'rationalistic' models of decision making in general had led already in the 70s and 80s to the emergence of *naturalistic decision making* studies that focus on understanding how people think outside the confines of artificial experimental settings and narrow data collection methods such as the infamous survey questions deployed by Tversky and Kahnemann (Kahneman & Tversky, 1979). Most prominently, Klein led large ethnographic studies of decision making in natural settings to understand how highly performing professionals effectively deploy their expertise and knowledge (Klein, 1998). His focus was on what he terms the *macrocognitive system* of decision making – the entire system of environmental cues, roles, incentives and structures, knowledge, prior experience, work processes, tools, available information, time constraints, etc. which influences the cognitive processes – understood psychologically and socially – which comprise *decision making* as a situated process. This view is akin to the well-known view of cognition "in the wild" (Hutchins, 1995) which has been influential in HCI (Rogers & Marshall, 2017). These naturalistic decision making studies have led to profound insights into the nature of expertise and skills, and the cognitive processes at work in experienced professionals (Klein, 1998). In Software Engineering, the focus of attention has been firmly on the normative, rationalistic perspectives and the associated research program of

heuristics and biases (Mohanani et al., 2018), with some notable exceptions that found significant evidence for the value of NDM in SE (Zannier et al., 2007).

In our previous studies, we found significant evidence that professionals acted *as if* they discounted the future (Becker et al., 2019; Fagerholm et al., 2019) – though whether it was because of perception or because of something like a discount factor, we do not know. In an ongoing large-scale study, we examine the cognitive processes at work in such situations using *Cognitive Task Analysis* methods developed by Klein and others (Crandall et al., 2006). The game *Undecided?* is a next step: By creating a simulation environment that playfully embeds a range of intertemporal choice situations in a group decision making setting, we hope to create a platform that allows us to study intertemporal choice in SE from multiple angles using many different methods.

3. The game: UNDECIDED?

Overview

Undecided? is an educational game that seeks to provide players with a general and integrated understanding of project management as well as software, product, and systems development. It is a tabletop game that uses a game board to simulate project phases and cards to mimic the actions undertaken and obstacles encountered in the development process. Players work together to complete a project, hitting milestones and striving for objectives throughout project phases. While *Undecided?* focuses strongly on collaboration, individual players also work to achieve personal goals corresponding to their role on the project team. This creates the possibility of moderating the tension between group and individual goals by varying aspects of the background scenario that provides a narrative frame for the game.

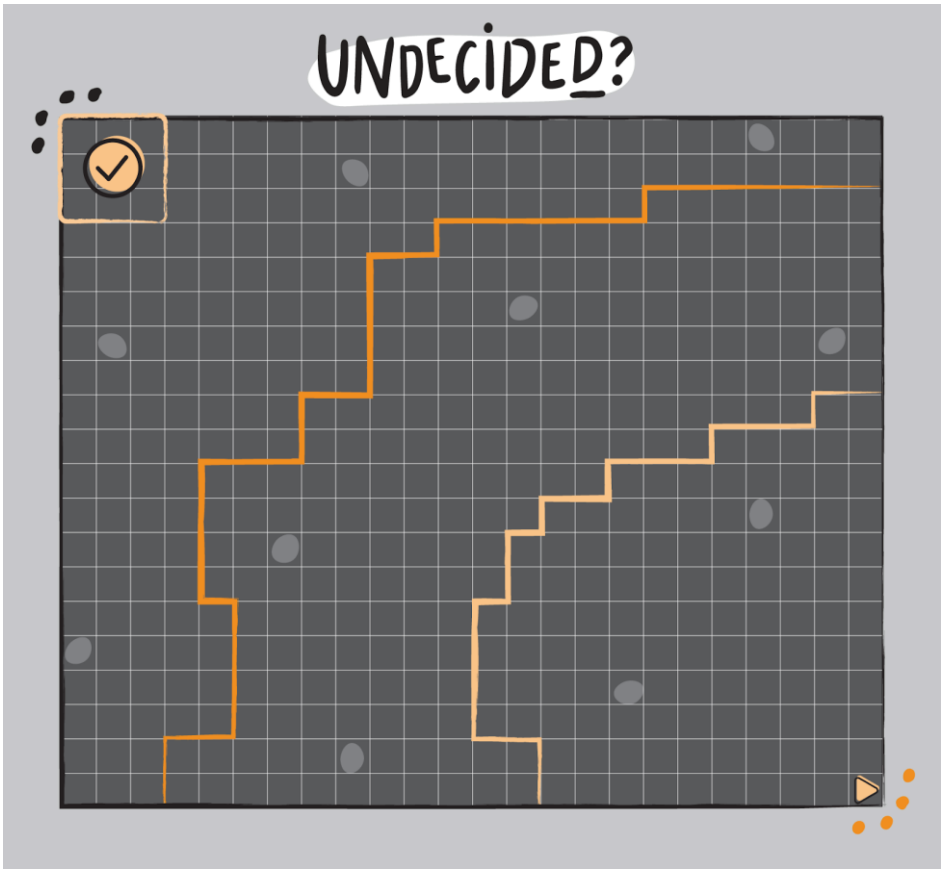

Figure 1 The start square is on the lower right of the board, the final gate on the upper left.

Undecided? is played on a rectangular board partitioned in three stages, with a start square in one corner and a target range in the opposite corner (shown in Figure 1). Each board facilitates play for one single team. Multiple teams compete by playing on adjacent boards. In each round of the game, the team draws cards and decides which of the cards they currently hold to play next. Playing a card means to place it

on the board, adjacent to a previous card, so that it covers eight squares. Crossing the gate from one stage to the next, shown by the colored lines, requires certain conditions to be fulfilled.

The team keeps a score on the following categories that represent the robustness of the project:

- **Internal** Quality of the software system under development
- **External** Quality of the software system under development
- **Process** Quality
- **Team** Strength

Each card – i.e. each possible action – will influence the team's current score on some or all of the four dimensions. How much exactly is revealed after the move is performed, but the card design indicates visually what will happen, as illustrated by Figure 2. Note that *Major Toolchain Upgrade* is the only intertemporal choice in this example set. The four dots indicate that the benefit on *Process* will manifest over the following four rounds. The orange semicircles indicate that there is a *risk* of negative effects. In contrast, architectural design and feature development are relatively straightforward positive contributions to specific aspects of the project.

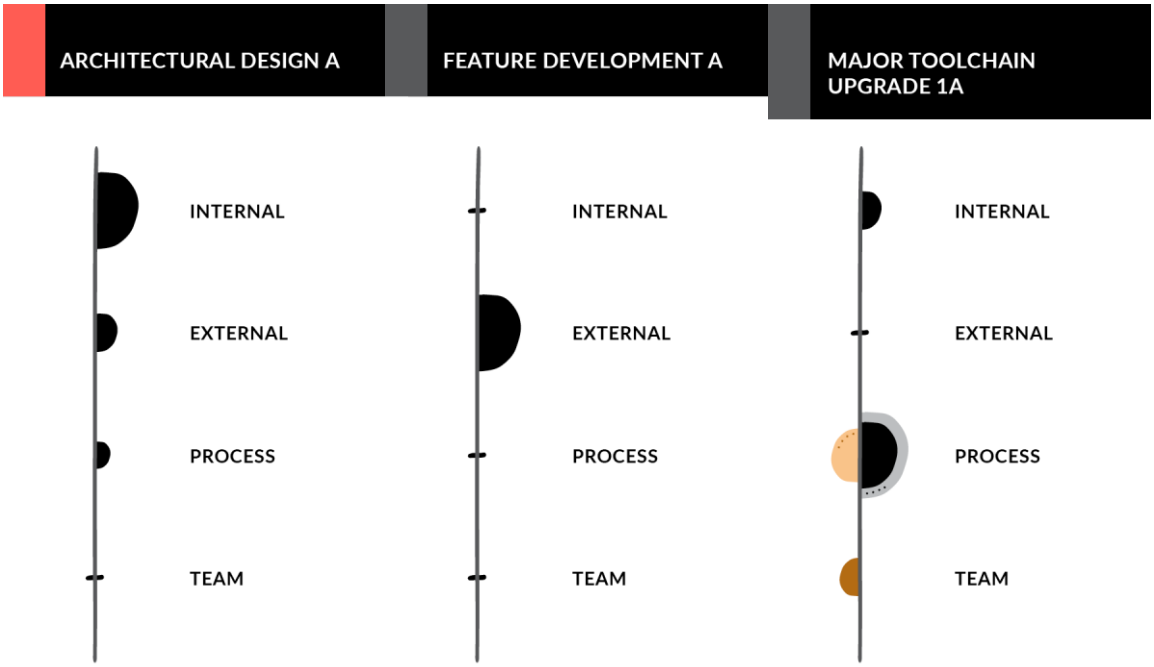

Figure 2 Selected action cards

Game play: Roles, Setup and Rules

A *game facilitator* is involved in the form of either a person who controls the game or an app (under development). The facilitator does not participate in play because they have access to secret information such as precise gate values and will determine how action cards are scored.

Player roles are determined before the game starts either randomly or through deliberation. Roles have various advantages when certain cards are laid, and outline role-specific goals that a player must meet to gain – or prevent the loss of – personal action points (AP).

Player roles are as follows:

- **UX Lead**
    - Focuses on External Quality
- **Team Lead**

    - Focuses on Team Strength
- **System Architect**
    - Focuses on Internal Quality
- **Technical Lead**
    - Focuses on Process Quality

Role-specific goals are representative of the overall standards of project management and development, with AP awarded to players if various cards are laid during certain project phases. (Action Points can be used collectively in specific "Blank" Action Cards.) For example, a UX lead receives +4 AP if a user studies card is played in the first phase, as it is generally regarded as an important step to consider early on in development. If a user studies card isn't laid in the first phase, the UX lead loses 4 AP to represent the impact of failing to determine user needs.

To set up, the Facilitator takes the Facilitator Notes. These are confidential: Players must not see them.

Players begin by reading their *Game Scenario*. The Facilitator reads their information packet based on the game scenario, keeping the contents secret unless otherwise directed. Players then set up the game board and shuffle the card deck. Players are assigned a role, either at random using a dice roll or through deliberation. Players then take their role description sheet. Next, the players draw 5 team cards from the deck and laid face-up in front of all players.

- If a "play immediately" event card is drawn at this point, return it to the deck and draw another card in its place. Examples of such cards are shown in Figure 3.

Figure 3 A sample of "Play immediately" cards

Once all elements are in place, gameplay begins. The team lead goes first. The first card laid must begin on the start square, at the bottom right of the board.

Core Gameplay Loop

Players take turns by moving clockwise around the table. Players begin their turn by drawing a card from the deck.

- If the card is a "play immediately" event card, the player lays the card on the board, follows the instructions, and ends their turn.

The player then consults their team to determine the next card to lay. Though collaboration is encouraged, the current player makes the final decision as to what card is laid.

- If a *Blank Action* card is in the hand, players can ask team members to contribute their AP points to the card. If the player is a senior-level team member, they can take as many action points as desired from team members. (Yes, there is a level of cruelty to that.)

The card is then laid on the game board so it is touching the edge of at least one other card. Cards can be laid in any orientation as long as it follows the grid pattern on the gameboard

- If the card is laid over an Event Square (grey circle), the current player partakes in the event, then ends their turn.

Cards can only be laid in the current project phase, unless the team wishes to attempt a *Gate Pass* and move onto the next project phase.

Gate Pass

A *Gate Pass* is initiated by a player laying a card across one of the orange borders on the game board.

All players, except senior-level players must then take part in a project review, constructing a narrative of their project up to the current point. The Senior-level player(s) then select the player with the best project story, and award them +3 AP if the gate pass is successful.

After the project review, the gate scores are revealed. If the team's scores exceed or equal the gate scores, they move into the next project phase.

If the scores fall short in any category, the player must leave the card on the board and turn it over. This card becomes a "dead" card and does not add to the team score, with the additional punishment of blocking part of the gate. The current player's turn is then over, and the team must continue to build their project in the current phase and attempt to pass again by repeating the process.

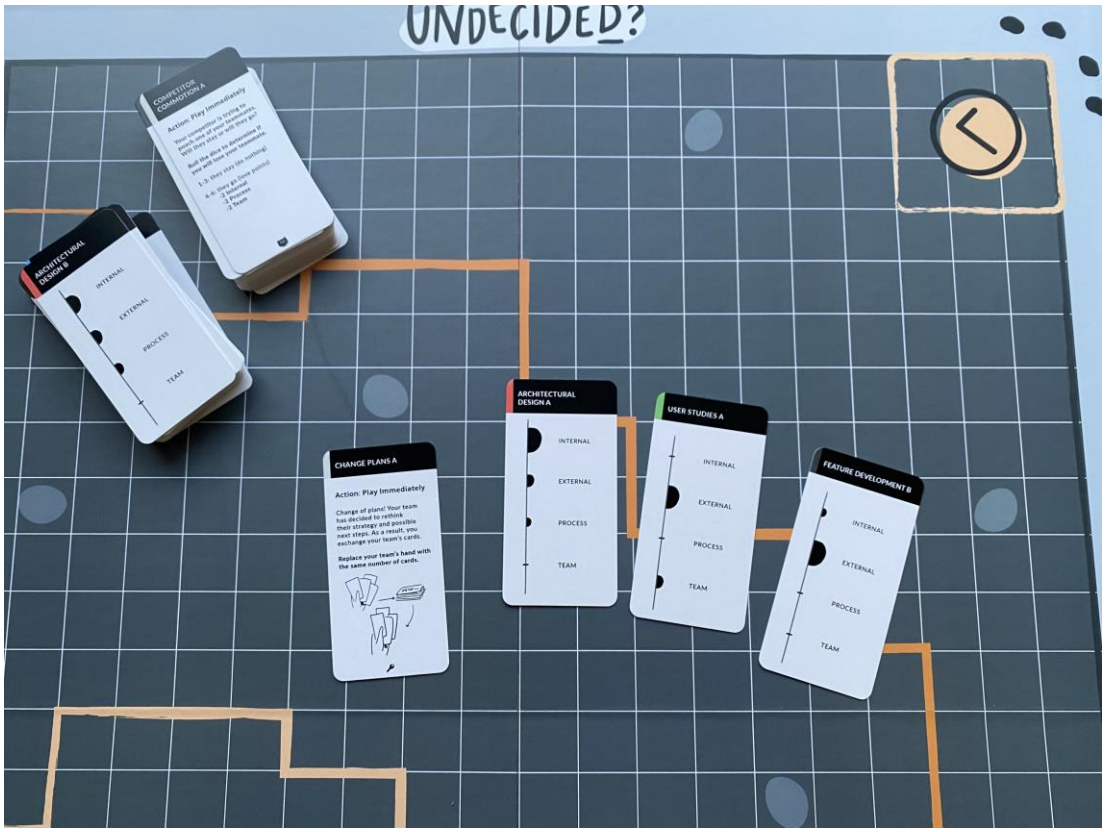

Figure 4 Partial view of an Undecided? board with selected cards

Winning/Losing the Game

The game is won when the team passes the final gate on the game board.

- After the final gate is passed, final scores are tallied.

The game is lost if:

- The team runs out of room to lay cards on the game board.
- The team runs out of cards in the deck
- The team makes a choice in a *Game Scenario* that triggers a loss state.

Figure 4 shows parts of a finished board with selected cards.

Cards and Scoring

Each move consists of playing a card. Each Card represents a prototypical action that the team can take. The team is scored on the four categories that represent the robustness of the project:

- **Internal** Quality of the software system under development
- **External** Quality of the software system under development
- **Process** Quality
- **Team** Strength

Points in each category are earned through the laying of cards on the game board.

When a card is laid, the facilitator uses their **score sheet** to determine how points are distributed.

- Some Event Cards are scored based on a dice roll. Dice rolls result in a success or failure of the event/action. In this instance, the facilitator must input the result of the dice roll into the score sheet for the score to be calculated.

The game scenario determines what scores are needed in each of the four categories for the players to progress through project phases.

The game facilitator uses a predefined spreadsheet to determine score values for the team. The facilitator is in charge of inputting the title of the played card into the sheet, and of reading the score values of that card aloud once they have been calculated by the sheet. A *Facilitator Notes* document provides specific instructions.

Scenarios and Major Events

The game is structured by the main narrative. Currently, we offer two narratives:

- In *Angry Cats*, the team is part of a start-up game studio and has just signed a contract with a prominent publisher to develop a new game and bring it to market.
- In *DysTalk*, the team has formed a start-up to develop a secure communication and networking product.

Each scenario comes with one major event that happens at an undisclosed point in the game. The event is triggered by external forces and will pose a significant intertemporal choice to the team outside the regular game play. But we shall not give away what it is – where would be the fun in that?

Moderation, online game play, and app development

As mentioned above, the game is based on some form of facilitation – in the initial deployment, that is a human moderator using a macro-enabled spreadsheet, but we are also developing an app that handles the game mechanics. The game cards are equipped with individual QR codes that can be scanned in order to make a move, and the app will take over the facilitation role once developed. We envision that the app may also

- Facilitate team competition,
- Incorporate educational content such as short explanatory videos,
- Facilitate a playful interaction across time between different teams, and
- Allow a board-less gameplay that facilitates remote group play with virtual cards.

To accommodate the pandemic circumstances, the visual game materials were imported to an online whiteboard to facilitate game play in parallel breakout groups, as shown in Figure 5.

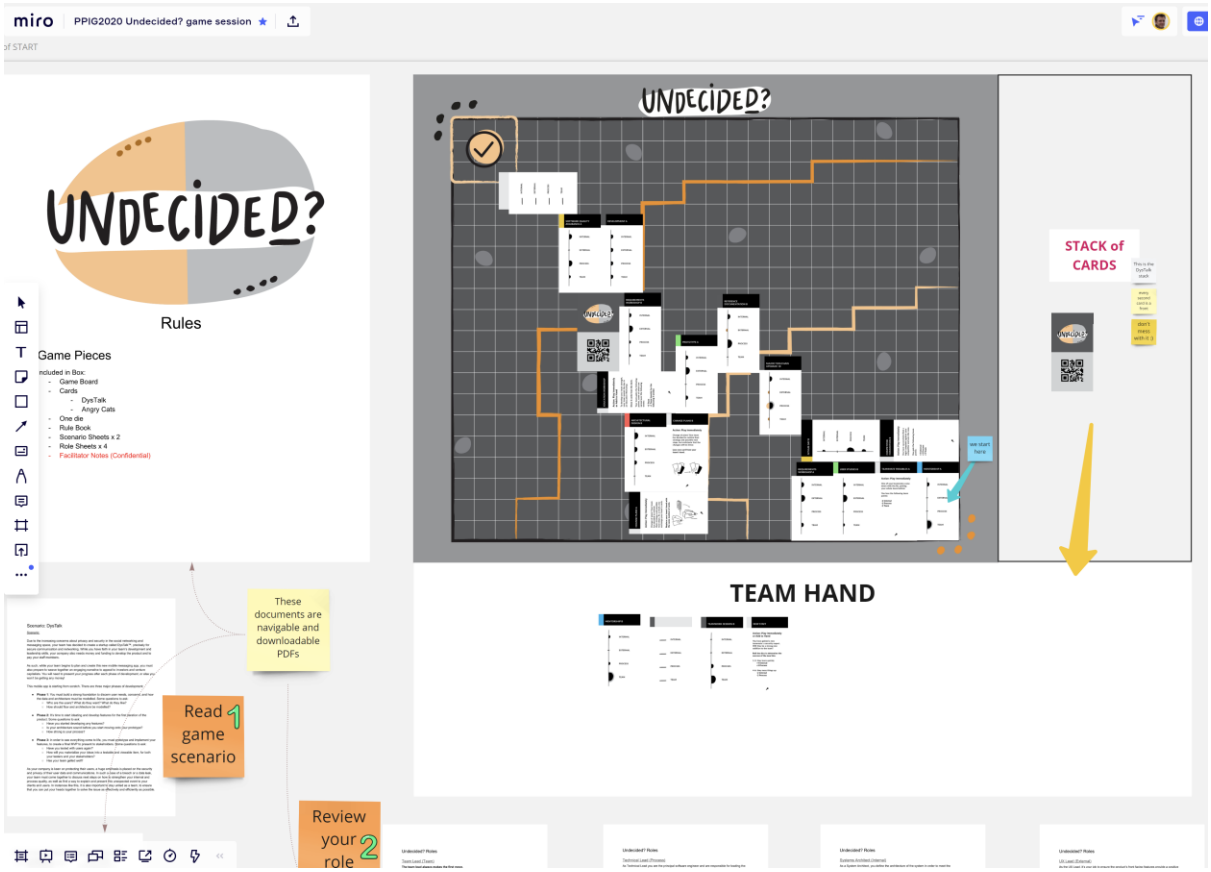

Figure 5 Segment of the online board game environment at PPIG 2020

4. Intertemporal Choices in *Undecided?*

Intertemporal choices in this game come in two different forms: routine and exception. The routine choices arise out of a subset of cards that carry intertemporal components, as outlined above. The exceptional choices arise out of the major game event that strikes the team along the course of game play and requires their attention.

The choices differ in several key dimensions.

- **Uncertainty and ambiguity.** The exact size of effects is uncertain – both spreadsheet and app employ simple randomizing functions. But there is also an element of ambiguity since the probability distribution remains blurred for the players. The visual design of effects as variously sized dots represents an intentional effort to keep game play from becoming a numbers' game. We do not want players to directly calculate the maximum number of achievable points and devise some heuristics, as that would circumvent what the main focus of interest is – the deliberation around the various dimensions and time. By developing such a heuristic, a player would in fact be playing a different game. In our prototype game play sessions, this worked quite well, but will need to be evaluated more rigorously.
- **Temporal and social distance.** Through their team roles, players are tied into a focus on certain dimensions. They become spokespersons for those dimensions, and they may in some situations not mind a loss in other dimensions. However, it is clear at all times that the team can only win collectively.
- **Large vs small outcomes.** Routine actions carry smaller weights, while the major event carries larger implications and highly ambiguous risks.
- **Explicit vs implicit choices.** The selection of cards provides a very explicit – and not entirely realistic – choice of possible actions. This is in some sense a limitation – NDM researchers such as Klein have argued convincingly that *comparative evaluation* of clearly enumerated alternatives

is often not the focus of real-world decision making under time pressure. However, some choices are more implicit, and some types of cards carry an open-ended scoring scheme that allows the team themselves to decide what action to take and how to label it.

- **Rhythm.** The regular routine choices come in each round, but some action cards are labelled "play immediately" and thus disrupt the cycle of deliberation, choice and status update. The major event is initiated by the facilitator, and not mentioned in the instructions for players, so it is designed to catch them by surprise.
- **Deliberation, choice, and reflection.** Each round will typically involve a phase of discussion resulting in a choice. Different configurations of roles can be deployed. However, some hierarchy is foreseen through the introduction of senior roles, and some choices can be taken by senior roles that affect others and can overrule others. Finally, the narrative reflection requested at each Gate Pass provides a retrospective that places the players into a narrative mode quite distinct from the deliberation and choice mode. Players can get quite creative in the story they tell at that point.

These design choices were made to facilitate a range of interventions and study designs to allow us to examine how individuals and groups reason; how variations in the setting may influence their choices; and to provide a situation that we can observe and retrospectively analyse using techniques from Cognitive Task Analysis.

To deliver educational value, we anticipate the game should be embedded in a workshop setting with a debriefing session that explores the nature of intertemporal choice and its role in software projects and includes a guided team reflection. It should also ask: *What is realistic about the game? What isn't? How is reality different? How and where are intertemporal choices hiding in our practice? Do we need to change the way we approach such choices, and how?*

The next section outlines a range of study designs we envision.

5. Research Designs

This section shortly outlines a range of envisioned uses of the game as a research platform and some of the possible choices and challenges in study design. We first outline a range of instruments, interventions and data collection methods that are of relevance in this setting, then outline possible study designs with concrete aims and combinations of instruments.

- **How to measure discounting**: As discussed in previous studies (Becker et al., 2018; Fagerholm et al., 2019), there are various ways of measuring the amount to which participants discount future outcomes, and a choice has to be made for each study which is most appropriate. In our recent studies, we opted for a more robust measure of the general amount of discounting over time per participant called *Area Under Curve*. It is worth mentioning that: (1) the amount of discounting varies wildly across participants in our studies (Fagerholm et al., 2019) and across studies in general (Frederick et al., 2002)(2) some of our participants do not exhibit discounting at all. It is therefore well worth examining the range of individual responses to explore possible reasons and forms of reasoning or the absence thereof.
- **Demographics** and differences in individual players should thus be explored. In our prior studies, we found no effects of education nor the amount or area of professional experience on discounting, but identified a significant effect – the larger the *range of* professional experience, the less participants discounted (Fagerholm et al., 2019), pointing to a possible role of empathy in how psychological distance affects discounting (Weber, 2006).
- **Time perception**, instead of discounting, has been proposed as an explanation for the appearance of discounting behavior (Zauberman et al., 2009). In that study, participants were asked to draw a line and to evaluate the length of lines in relation to time. A similar instrument could be deployed to establish individual differences in time perception before game play.
- **Think Aloud Protocol** analysis can be used to a limited degree in a group setting, but it can be useful in individualized game modes such as online game play.
- More generally, **Cognitive Task Analysis** offers an entire toolbox of methods including interviews using Critical Incident Method for retrospective interviews as well as observational methods that can be deployed non-obtrusively in game play settings.

- **Surveys and interviews** support an evaluation of the game from the perspective of participants in terms of educational value (short-term and long-term learning outcomes) as well as enjoyment value (short-term) and possible side-effects (e.g. team formation, interpersonal relations)
- Finally, we hope to explore the effects of **interventions** on intertemporal choice, guided by emerging insights such as the possible role of empathy in overcoming psychological distance; the role of specific education modules (such as technical debt) on discounting; or a range of priming effects. For example, the Empathy Toy® is "a blindfolded puzzle game that can only be solved when players learn to understand each other", a playful way to activate empathy skills in players (*The Empathy Toy*, n.d.). Would its use before game play influence the choices made by participants?

Of course, the range of choices made for each concrete study will have to involve a careful configuration of designs, instruments and interventions fit for the purpose and methodological assumptions of the study. For example, a study could examine the role of group composition and incentive structures on reasoning strategies and discounting outcomes. The roles embedded in game design involve a few structural conflicts of interests, but they are built toward an overarching team interest. Different instructions for each team member, and different incentive structures, could be used to explore how they affect people's reasoning and group dynamics. This would involve a very different design from a study to explore to which degree the sensitization to intertemporal choice arising from playing the game leads to future shifts in discounting behavior on the side of participants.

We currently aim to prioritize the following types of studies ourselves.

- In **Cognitive Task Analysis** studies, we aim to observe game play in groups and conduct retrospective interviews with groups and/or participants, supported by additional data collection instruments including pre- and post-game surveys and measures of discounting.
- In **Randomized Control Trials**, we hope to assess the effect of
    - **Interventions** outside the game such as an empathy workshop or the delivery of an education module, as well as
    - **Variations in game design** that vary the *architecture of choice* that shapes and configures how participants enter the choice situation and which information is presented to them. This can involve variations in the time scales and how they are presented – for example as weeks, months or sprints; variations in the language used to frame outcomes; variations in the emphasis given to gains and losses; or simply variations in the instructions given to individual players.
- We aim to explore **the game *as intervention*** embedded in a workshop, in industry or community settings. We envision the first rounds of this as Action Research to explore the possible values and effects of the game and associated workshop, and to identify future directions of game design and development. This could eventually lead to a more quantitative validation of the game's value, which requires a clearly identified dependent variable such as the amount of discounting exhibited by a team or person. That needs to be measured through a validated instrument, for which our previous study design may provide a starting point (Fagerholm et al., 2019).

6. Conclusions

Choices involving uncertain future outcomes that are spread in time – so-called intertemporal choices – abound in software projects. Multiple factors impact how such choices are made, including the uncertainty and ambiguity of the options and outcomes, the combination of favorable and unfavorable outcomes at different points in time, and the psychological distance to people who are affected. This macrocognitive view of decision making situates the cognitive processes of decision-makers in the social environment.

We have previously examined intertemporal choices in software engineering and found evidence for extensive discounting, but also of large individual differences (Becker et al., 2019; Fagerholm et al., 2019). However, what determines the choices is still unclear. The board game "Undecided?" simulates a software project through a series of intertemporal choices made by players in teams. The game is educational and fun, and it aims to provide a platform for cognitive and social studies of decision

making in software projects. This paper describes the game and outlines possible research designs in which the game is used to shed more light on how decisions are made in software projects.

7. Acknowledgements

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