

AN INFORMAL SUMMARY OF

EVALUATING THE ADVANTAGES OF PHYSICAL AND DIGITAL ELEMENTS IN HYBRID TABLETOP GAMES

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1 Preface

A few weeks ago, I finished my studies at the [HTW Berlin](#) in International Media and Computing with the defense following my master's thesis. I thought that its content might be interesting to others on the internet too, but I understand that not everyone wants to read 100+ pages. For that reason, I am now writing this "too long; didn't read" summary. It is also a lot more informally written. If you like what you read, you are quite welcome to read the longer version too! Here are the links:

- [Master's Thesis](#)
- [Source Code \(open source, MIT license\), Screenshots, Photos, Videos etc.](#)

If, by chance, this is a printed version, you can find a blog post containing the same content as this document with working links and embedded YouTube videos here:

<http://blog.dragonlab.de/2014/12/thesis-hybrid-tabletop-games>

2 Introduction

I love board games just as much as I love digital games. With smartphones and tablets, digital board games are getting bigger and bigger. But those are mostly touch-based - and at the HTW I had the chance to make games with a [MultiTaction Cell multitouch table](#) which can recognize objects placed on top of it too. So now, in my thesis, I wanted to find out if I can create digital-physical tabletop hybrid games that provide better gameplay than a touch-only version could.

I didn't want to do something like chess which could be played with physical tokens, as a touch-based digital game or as a hybrid game without changing gameplay at all. I set out to focus on game prototypes where neither the digital and physical elements could be removed without changing the gameplay - a "true hybrid", only possible in combination. Core physical elements should be interactions with advantages in the physical world, for example using the sense of touch to quickly and intuitively manipulate objects without directly looking at them, real-world physical interactions between pieces or using other properties of physical artifacts – e.g. objects can look different depending on the viewing angle. Likewise, the digital aspect is not just used for the sake of technology, but to add gameplay elements that are only possible by using technology.

I quickly figured out that it is easy to make the digital side matter, but almost everything physical that the multi-touch table can still recognize can also be closely simulated digitally. This shifted the focus a bit: Instead of still trying to make "true hybrids", I wanted to make tabletop game prototypes that I believe are improved by the physical/digital combination. Every

prototype would get a hybrid and a touch-based-only version, and then I can compare those in user tests.

3 Physical/Digital Advantages

Before I started with the design of the prototypes, I analyzed board games and digital games to find out which advantages they have over the other side. Note that a lot of those have exceptions, e.g. digital games are more likely to have a tutorial, but there are also [board games with tutorials](#) - and flicking might have advantages in the physical world, but [digital games have similar mechanics](#). Mechanics and properties that are listed here are not exclusive to either side; I just believe that one side does it easier or might do it better in some way.

My thesis also has a short chapter on pervasive games, but since the focus is on making a tabletop hybrid game, I'll leave this out here.

3.1 Physical Advantages - with a focus on board games

3.1.1 Physical Interaction

The physical world provides tactile feedback and often allows for more fine-grained movement.

- **Finger Flicking:** Done in games like [Carrom](#) and [Crokinole](#), sometimes also thematic games like the dungeon-crawler [Catacombs](#). Can be simulated with quick swish-motions on touch screens or pull-back mechanics in the digital world.
- **Gravity:** Games like [Bausack](#) or [Jenga](#) are built around building, balancing or removing building blocks in 3d space. It is hard to simulate the small movements and the tactile feedback in a digital game, although many 2d physics games exist.
- **Tools:** Games like [Operation](#) or [Gone Fishin'](#) are based around tools used to interact with the game to give it a certain feeling or mechanics. These are much easier and often cheaper to produce for a physical game; the digital equivalent would be custom controllers.

3.1.2 Hidden State in a Shared Space

Tabletop games use independently movable physical parts which allows players to look at information (for example the underside of a card or token) without the other player seeing the same information. This is not possible on a single shared digital screen on multi-touch table or tablet. Digitally, this can be solved by using multiple screens or having a player look away, so either the space is not shared anymore or the flow is often broken.

3.1.3 Player Interaction

Interacting and communicating with other people is much easier when the partner is in the same room, instead of through text and speech or even through a webcam.

- **Communication and Party Games:** Games like [Taboo](#), [Pictionary](#), [Charades](#) and [Freeze](#) are heavily reliant on communication - be it speaking, drawing, gesturing or full-blown acting. Speaking and drawing can be replicated in digital games as well and might just be more enjoyable in a setting with everybody in the same room; when more body language and atmosphere is involved though, making a digital equivalent might be harder or even impossible.
- **Reading People's Faces:** Games like [Junta](#) or those in the [Werewolf/Mafia](#) family are heavily based on observation, negotiation and/or calling people's bluffs - "reading" people. This can be done digitally and online too, but it is a totally different experience.

3.1.4 Flexibility

Board games are fully executed by human players. This allows for a certain kind of flexibility.

- **House Rules:** Rules could be improved? Easily changed.
- **Games about Making Rules:** Games like [Hex Hex](#) or [1000 blank white cards](#) take it one step further by allowing the players to make up new rules or even design all game components and interactions.

3.1.5 Other Advantages

- **Components:** Physical components are often cheap and dependable. Digital devices on the other hand need to be bought, and assuming that players have smartphones doesn't hold true everywhere.
- **Available Space:** Big touch screen are often very expensive, while producing a table-sized board game might not be exactly cheap, but still much cheaper.

3.2 Digital Advantages

3.2.1 Tutorial

In the board game world, learning a new game usually means reading a rulebook – or being taught by somebody who already knows the game. In the digital world, the learning companion can be the game itself. Digital games can enforce rules, teach when appropriate and react to players faults more easily. (Although [Legends of Andor](#) does a pretty good job at having a board game tutorial - inspired by digital games, no less.)

3.2.2 Control

In digital games, the experience is fully controlled by a processor: Input is taken and used as seen fit instead of direct interaction with the game pieces like in board games.

- **Setup Time:** Even after learning the rules, physical games still have to be prepared manually. The worst you will usually get from a digital game is a bit of loading time.
- **Automatic Data Processing:** Menial counting tasks and figuring out action results can be taken care of swiftly and automatically.
- **Information Display:** The game can show predictions and context-sensitive information when needed.
- **Distance Calculation:** Instead of moving in a visible grid or graph, movement can instead be by distance - and still does not need external tools like a ruler.
- **Real Time Play:** Automatic data processing also allows real-time play since it can instantly compute outcomes and it can limit players action, for example via a cooldown delay or resource usage.
- **No Room for Player Errors:** The game executes all the rules itself. If players haven't understood a rule, it will still happen like it was originally intended.
- **Cheating Inhibition:** While technical cheats are possible, those are far less casual than looking at enemy cards in a board game or switching pieces while an enemy has left the room briefly.
- **Impartial Judgment:** Knowing everything that happens perfectly at any time and favoring nobody, digital games can easily judge results.
- **Artificial Intelligence:** Processing power enables stronger and more interesting non-human enemies than board games.
- **Hidden State Processing:** Hidden state can be automatically worked with in a truly hidden way. Considering a shared screen space, a game could still process what a hidden card does, for example mining one gold nugget per turn which the player could already use without revealing its source.
- **Hidden Actions/Communication:** When a player has their own device available, they can take hidden actions with the game verifying that this action is actually possible – thereby allowing hidden actions without fearing that the other player cheats. In the same vein, this could allow communication between players without a third party knowing that this takes place at all, for example to form secret alliances and plan combined actions.
- **Sensors and Input Devices:** Digital processing allows games to use sensors and interesting/complex input devices and integrate them into the gameplay.

3.2.3 Content

- **Storage Capacity:** So many games on such a small disk.
- **Procedural Generation:** Levels and playing fields can be created by algorithms on demand - with agency and configurable.

3.2.4 Presentation

- **Animation:** Board games mostly have static visual elements that are moved around. Digital games can change or animate those elements according to actions and game state.
- **Sound Feedback:** Obviously, the real world has sound feedback too, for example when placing a token - but here, digital games can play sound specific to what a token or action symbolizes, for example a cat token that meows when it gets a fish token.
- **Atmosphere:** Changing visuals and added music can greatly increase the atmosphere for a game.

3.2.5 Logistics

- **Location:** Tablets have much smaller screens than a board game would need. Suddenly, [a big board game might be playable in a coffee shop.](#)
- **Availability:** No need to wait for a physical order to arrive - digital games can mostly just be bought online and downloaded instantly.
- **Updatability:** Game content and rules can be updated later via online updates.
- **Persistence:** When a game takes too long to finish, it can be saved and later restored. Unlike most board games, that makes it very easy to move between playing locations too.

3.2.6 Online Play

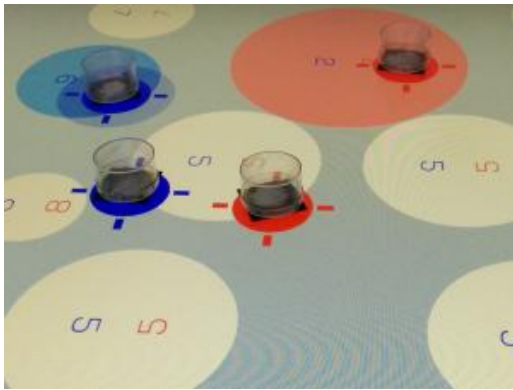
Digital gaming devices are often connected to the internet which enables playing with people who are not sharing the same room. This enables playing with friends who cannot meet personally at the moment, but it also allows strangers to play together.

Real-time online play is obviously used in real-time games, but also turn-based games often need everyone connected at the same time. On the other hand, the persistence of a server also allows **asynchronous online play** - players are not necessarily online at the same time, make a move, log out again and are notified once the other player made their move too.

4 The Prototypes

To find out whether having a physical/digital hybrid improves on gameplay, I made three game prototypes, each with a hybrid variant and a touch-only variant.

4.1 Finger-Flicking Game



The first prototype is a two-player versus flicking game with real-time scoring. Players flick discs into scoring areas, adding a new disk every few seconds. Sometimes it might be more advantageous to wait until the enemy goes first and then hit the enemy disk so it leaves the area it is in - and sometimes it might be better to quickly score in an easily accessible scoring area. The game ends after a fixed amount of time and the player with the higher score wins.

Here is a highly recommended YouTube video about the game: <http://youtu.be/TNeNzLivp4I>

4.1.1 Physical Part

The game uses physical tokens the player's can flick, which I believed to be more engaging than a purely touch-based version because it adds tactile sensations and real-life interactions. I also thought the players might easier learn how much force they need to flick properly because they know naïve physics and get haptic feedback.

4.1.2 Digital Part

The main digital parts are a) the real-time scoring and b) the timer which allows the placement of new tokens. The game also uses visual feedback: The background is tinted in the currently winning player's color and tokens which are scoring higher amounts emit bigger visual "waves".

4.2 Spaceship Game



In the Spaceship Game, two players cooperatively manipulate a spaceship with attached satellites in real-time. The satellites have different turrets, shields or supporting structures. The goal is to survive as many waves of enemies as possible.

Here is a highly recommended YouTube video about the game: <http://youtu.be/Bhc3SKKhF3A>

4.2.1 Physical Part

The physical spaceship is a direct representation of the digital spaceship. Players get instant tactile feedback on their actions, and resistance and the feeling of tugging might make it easier to cooperate. Turning and moving should also be easier when working with a wheel instead of a touch screen.

4.2.2 Digital Part

The game simulates enemies coming at the player in real-time while also operating weapons, moving projectiles, resolving collisions and keeping track of hit points. This cannot be reasonably done in a non-digital tabletop version while keeping the real-time element.

4.3 Duel Game



The Duel Game is a turn-based two player versus game. Both players have five units with different roles: Berserker (does most damage), Guard (has most health, strong counterattack), Marksman (ranged attack), Ninja (can try to jump out of attacks and switch with a unit once per game) and Spy (can get direct information about enemy tokens). Their positions are secret and players also secretly assign power levels from 1 to 5 to them. In the following fight, players move and attack with the units, using their respective strengths and abilities, trying to find out what the enemy units are and to take them down. Once a player has lost all their units, the other player wins.

Here is a highly recommended YouTube video about the game: <http://youtu.be/i9SafB3oBQM>

4.3.1 Physical Part

The tokens with the cardboard screens allow two players to play on the same screen space without any indirection and still have hidden information.

4.3.2 Digital Part

The game contains several parts would be very hard to remake in a purely physical tabletop version.

Firstly, the rule set of interactions and reactions is a bit complicated. Having this done automatically is quite helpful.

More importantly, the game contains several parts where you would need an external judge:

- Fights are done in a doubly blind way: The attacking player knows a range of damage they can deal (for example 1-6), but they don't know how much damage they did in this attack. On the other hand, the attacked player only knows that how much damage they took (for example 3), but not how much the opponent could have done.
- The Spy can see information about enemy pieces without the enemy even knowing that they have been spied upon.
- The Ninja can switch once with a friendly unit without informing the enemy player.

5 Test Results

5.1 Approach and Caveats

First off, this thesis did not have any budget or people to organize the search and testing, so it had only 12 probands in total. Additionally all the probands knew the author, with some even knowing the title of the thesis and a bit more information about it. I am fully aware that makes the results not very representative and less trustworthy, hence this caveat. The following is written in the hope that you still find it useful, if only for pointing in a general direction.

Each test session consisted of two players playing against each other. Many people played multiple games. A typical evaluation session looked like this:

1. The author of the thesis explains the game (5-10 minutes, depending on complexity)
2. The participants play a version of the game (5-20 minutes)
3. The participants separately fill out an AttrakDiff form for this version (5 minutes)
4. The participants play the other version of the game (5-20 minutes)
5. The participants separately fill out an AttrakDiff form for this version (5 minutes)
6. The participants separately answer the comparison questionnaire (5 minutes)

The [AttrakDiff](#) A/B test resulted in barely any difference between the two versions of each prototype, so I won't mention it here.

In the comparison questionnaire, players rated 7 questions from 0 to 6, with "0" being "Hybrid" and "6" being "Touch-only". The italic text explains the motivation of certain questions and was not part of the questionnaire sheet.

1. "Which version was easier to use?"
2. "In which version did you feel more in control?" *(In games, less control does not always equal less ease of use. The Finger-Flicking Game might be easier to target in the touch-only version, which might make feel people more in control there, but the hybrid version might be easier to use due to less indirection.)*
3. "Which version was more fun?"
4. "Which version was more interesting?" *(This question tries to find out whether the hybrid version provides novelty value beyond pure gameplay.)*
5. "Which version felt better?" *(This question tries to capture whether the sensations provided by the tactile feedback add to the experience. It is deliberately vague to refrain from influencing people towards the hybrid version.)*
6. "In which version did you feel closer to the other player?" *(This tries to contribute to two questions: Do digital games feel more like playing "with the screen" instead of "with another player"? Does playing together on one screen in the hybrid version of the Duel Game make a noticeable difference?)*
7. "If you had to play again, which version would you choose?"

5.2 Finger-Flicking Game

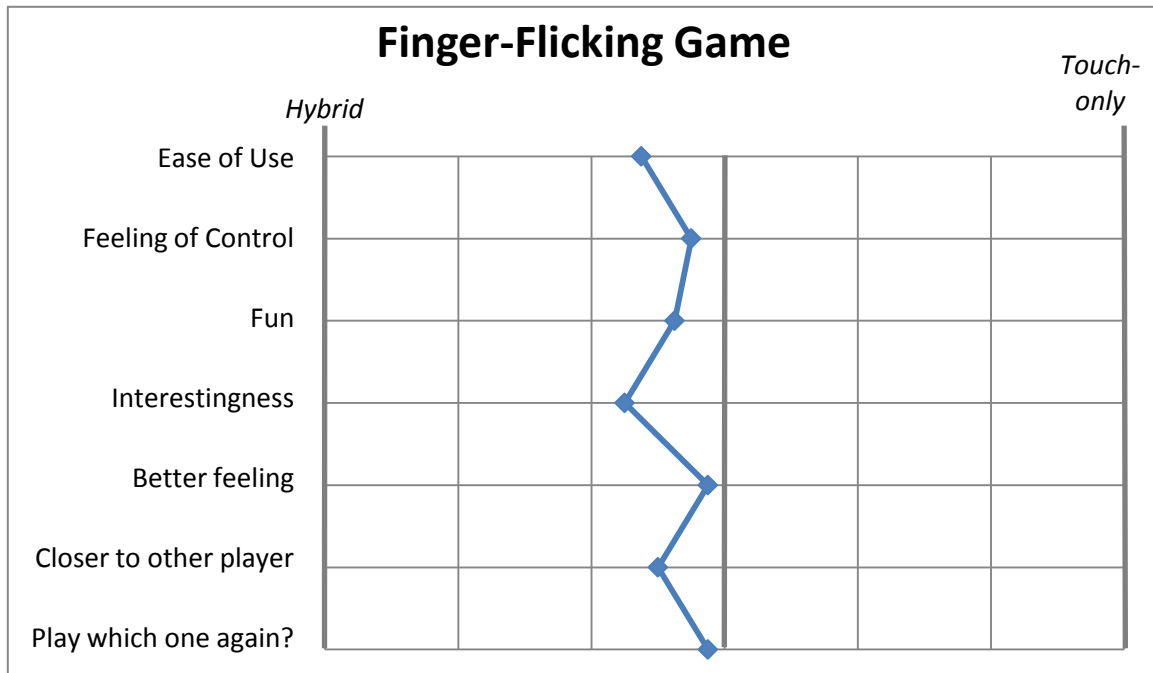
5.2.1 Hypothesis

In the hybrid version of the Finger-Flicking Game, the physical tokens are easier to handle as people can quickly figure out how they behave physically. The tactile feedback and the physical interactions between tokens feel gratifying and make the game interesting, but also a bit unpredictable. Only a limited amount of tokens needs to be introduced and recognized by the table at any time, so the friction between physical and digital world is kept to a minimum.

The moves in the digital version are a bit more predictable. Flicking by swiping is easy to figure out and easy to execute, but it takes more tries to learn how far a swipe will take the token. Moving a token by tapping it first is a bit harder to learn because it is not intuitive.

Depending on the players' preference, they might prefer the tactile feedback and unpredictability of the hybrid version or the predictability of the digital version. The hypothesis was that the games will be fairly evenly rated with a preference for the hybrid version.

5.2.1.1.1 Results



The Finger-Flicking game had 8 testers. All average values tend slightly towards the hybrid variant in various degrees. Especially interesting was the wide range of answers – for example in the “Feeling of Control” category, 3 of the 8 players answered that the Hybrid version is clearly superior while 3 tended slightly and 2 strongly towards the touch-only version. Here it seems to come down to preference, which is in line with the hypothesis for this prototype.

It is worth noting that both of the versions proved to be imperfect. The physical tokens in the hybrid version could be weightier and slide better and especially two testers had recognition problems; meanwhile, the digital version has a lag (by recognition algorithm design) when flicking, with the token not moving until the flicking gesture ended. I believe that if the recognition was stable and the physical properties of the hybrid version were more optimized that the hybrid version would be more strongly preferred. It would have been interesting to do more iterations of each version to finally compare “idealized” versions where each is as good as possible.

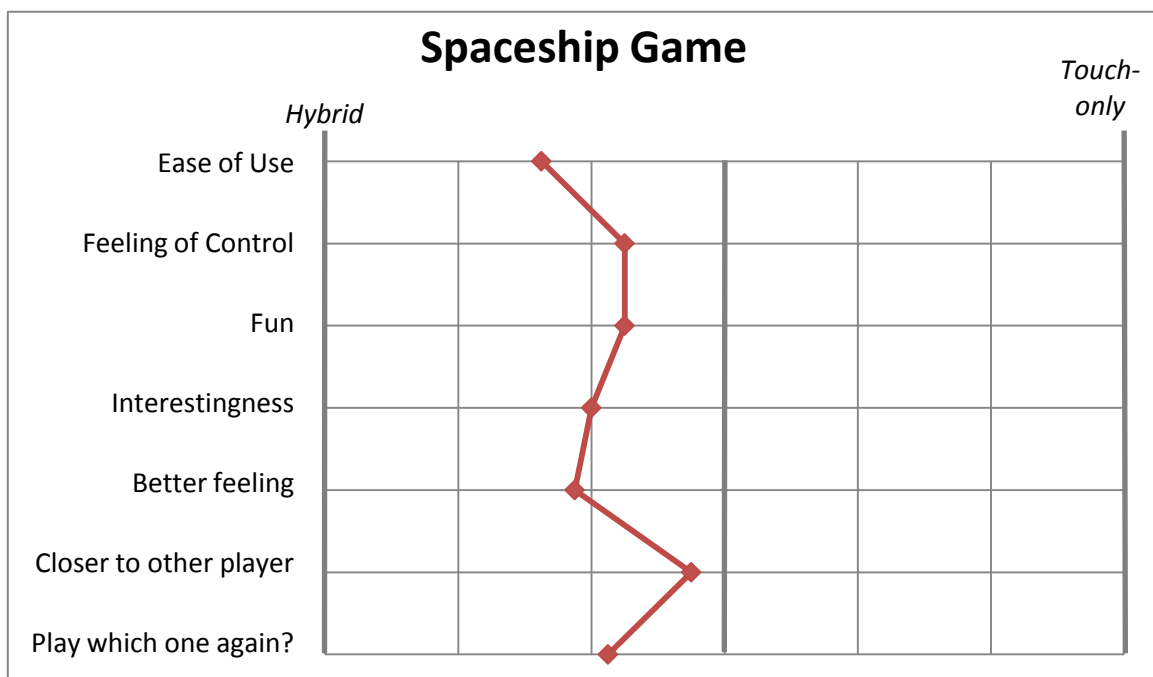
5.3 Spaceship Game

5.3.1 Hypothesis

In the Spaceship Game, the physical feedback provided by the components in the hybrid version is essential. The tangibility allows for faster targeting than in the digital version (albeit it sometimes lags slightly behind), and grabbing and turning a wheel is easier to execute than constantly rubbing two fingers over the glass to turn and move a token. The physical constraints help players feel the movement restrictions and coordinate activities – for example when a player tries to evade a bullet by tugging, the other player might loosen their touch to allow the movement to happen. Additionally, the Spaceship Game has only 5 physical tokens in total – the mother ship and 4 satellites. These tokens can be made unique/persistent which improves the chance to recover from recognition errors, and they only move slowly compared to the Finger-Flicking Game. This should help to reduce the friction between the physical and digital worlds.

The hypothesis here was that the hybrid version of the game will be strongly preferred.

5.3.2 Results



The Spaceship Game also had 8 testers. Here, the tendency towards the hybrid version is even stronger, especially for in the “Ease of Use” category. It matches with the hypothesis, although not as strongly as expected.

Players said that the rotation in the digital version was very hard (a direct turning with touch points was used, as if one was touching points on physical objects – maybe a rotation speed multiplier would have been good here) and one tester remarked that the hybrid version had an

unfair aesthetic advantage, with the simple graphics on the screen being the same, but the Lego model looking more interesting. One player said that the Lego model was obstructing his view and because of that he preferred the touch version, while others liked the look and feel of the model.

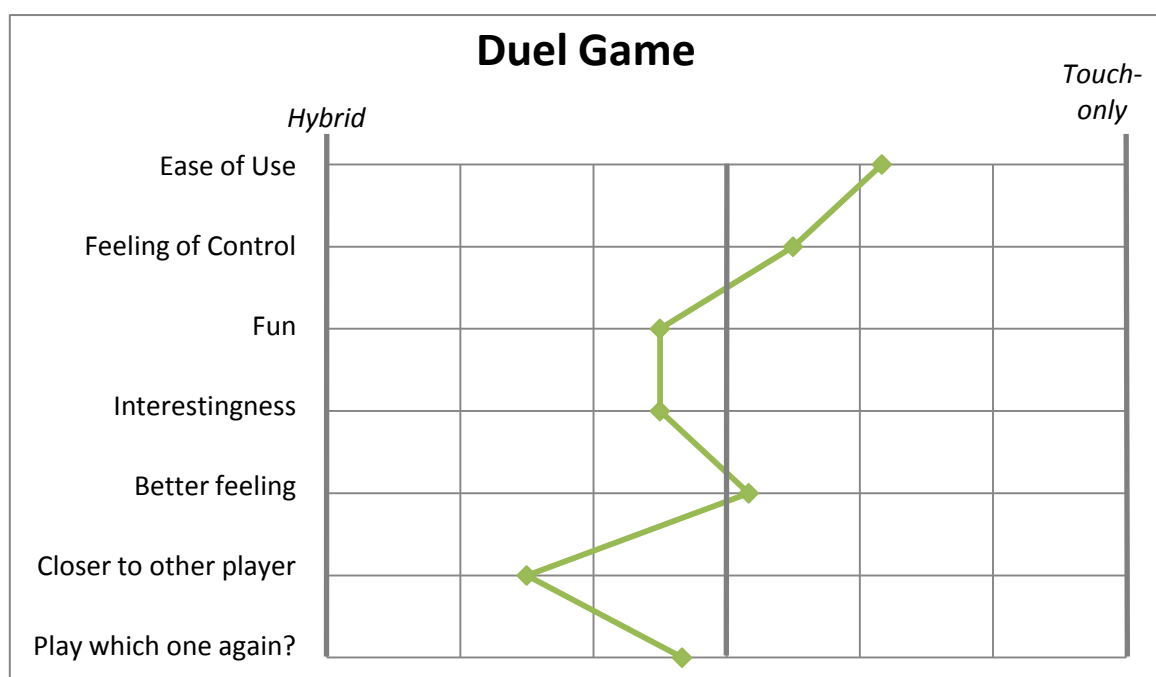
5.4 Duel Game

5.4.1 Hypothesis

The hybrid version of the Duel Game is the prototype that suffers the most from wrongly recognized tokens, as it contains 10 tokens that have to be properly recognized at the correct positions before the game can even start. This often involves moving around multiple markers to trigger a refresh and having some markers in unstable conditions. Putting the physical role info cardboard stand-ups into the tokens makes the setup phase lengthier, and there is a certain chance that a wrongly detected marker shows a hidden token to the enemy. When that happens the game has to be restarted and the token role info cardboard stand-ups have to be taken out and reassigned again. After the preparation, the game progresses more smoothly, but one still sometimes has to adjust unrecognized markers and wait for markers lagging behind so that the level/health etc. information does not get exposed to the enemy.

In the digital version, players are more distanced as they are not playing directly on the same playing field, but ease of preparation and play might make this version much preferable. It was therefore the hypothesis that in this game, the digital version will be preferred.

5.4.2 Results



The Duel Game had 6 testers. As expected, the touch-only version is preferred when it comes to ease of use and players feel slightly more in control. Despite players not showing strong tendencies about which version to play again, the goal of the hybrid version was reached: Players feel closer to each other because they play on the same field and see each other moving the tokens. One player in particular remarked that he felt that he was playing against the computer in the digital touch-only version, saying that his opponent is “right over there”, but he is still watching the screen instead of talking to him. In general, it seemed like more personal interactions were happening between the players in the hybrid version.

5.5 Summary

In general, the differences between the games are rather small, but they are not surprising. The hybrid version in the Spaceship Game provided a bigger improvement over the touch-only version than the Finger-Flicking Game, and the Duel game had more control problems in the hybrid version, but also brings the players closer together.

The differences between the hybrid versions and the touch-only versions are not very strong though, and individual testers preferred games on either side with just the average tending slightly towards the hybrid side.

5.6 Possible Future Evaluations

There is another thing to take away from the tests: Which future evaluations could be made. More information on the following list can be found in the thesis.

- Multiple iterations between evaluations to reach "ideal" hybrid/touch-only prototypes.
- Long-term tests instead of short "first impression" tests.
- Play tests in a non-laboratory setting, for example an installation.
- Tests between hybrid and physical-only board game versions.
- Tests with certain groups of people.

6 Conclusions

In the end, I couldn't demonstrate a strong player preference for physical elements in tabletop hybrid games, despite trying to give these elements meaningful gameplay character. There is a slight average preference to the hybrid versions, but it seems to come down to individual player preference.

Considering that hybrid games are harder to produce and have high and costly hardware requirements, touch-only versions might be preferable in most contexts - except maybe certain cases like permanent installations or museums where you only have a one-time cost.

It was rather hard to find advantages for the physical side that a) work with a touch table, b) cannot be simulated by touch-only and c) improve gameplay. Digital advantages on the other side were very easy to find.

It might be more promising to look at hybrid games away from the 2D interface of a touch table - games that are played in 3 dimensions, be it a stacking/building game or pervasive games where people use their own body and their environment, but also smartphones and other sensors. In games like these, a purely digital version should be a wholly different experience - unlike the prototypes presented here, where a touch-only version was believed to be inferior, but still easily creatable and comparable.

I imagine a game where a good portion of the game takes place in the physical world, but that uses the touch table as an interface to another part of the game, could also be interesting to play. In such a game, for example, cards could be obtained in a fully physical card game and be placed on the touch table to trigger effects there. The ease of handling cards in the real world could be a good argument for the making the game a physical/digital hybrid (instead of fully digital) if the interface is done correctly.

Another approach could be to concentrate even more on the physical-tactile aspect, for example by making a game that does not use visual output at all, but takes physical input and creates auditory and possibly tactile (vibrations, movement) output. Here, the screen of the table would not be used, only its recognition capabilities.

7 Libraries/Assets Used

The prototypes/videos use assets by:

- Music: [Kevin MacLeod](#)
- Sfx: [Moritz Ufer](#), [Iwan 'qubodup' Gabovitch](#), [carbillion](#)
- Font: [The Northern Block](#)
- Icons: [J. W. "eleazzaar" Bjerk](#)

Libraries used:

- [Uniducial](#)
- [TouchScript](#)
- [DOTween](#)