X-eo:

RESEARCHING & DESIGNING FOR REBLLIOUS PLAY

GRADUATION PROJECT
MSc DESIGN FOR INTERACTION

MARK KENT

I would like to dedicate this thesis to my late cousin, *Joeseph Caulfiled*. *"Joe"* was a child at heart; playful with a passion for media and technology and without a doubt he would of provided me with some valuable contributions to my project over the last few months if he was still here. Gone but never forgotten.

RIP.

X-eo:
RESEARCHING & DESIGNING FOR REBLLIOUS PLAY

Master Graduation Thesis

Mark Kent
Master Design for Interaction
Industrial Design Engineering

Faculty of Industrial Design Engineering,
Delft University of Technology,
Landbergstraat 15,
2628CE ,
The Netherlands

Under the supervision of

Assistant Prof. Matheiu Gielen
Assistant Professor, Design for Children's Play, Industrial Deisgn, TU Delft

MSc. Anna Ruiter
Teacher, Applied Ergonomics & Design, Industrial Deisgn, TU Delft

Graduation date
May 13th 2019

Executive Summary:

The Assignment

This reports the graduation project aimed to investigate the occurrence of rebellious play through the X-eo prototype. Rebellious behaviour is often referred to as going against the norm and derives its value from breaking rules. Previous academic research (Gielen & Van Leeuwen, 2013), on the subject, has provided suggestions and techniques to design for this. However, there has been no clear or obvious conclusion as of yet, whether or how rebellious play can be promoted and supported through design.

Therefore the brief for this graduation assignment was to " re-think the bangerik & develop the Bangerik concept and investigate the occurrence of rebellious behaviour during play. As secondary goals; gain insights in designing and researching for rebellious play."

X-eo builds upon the bangerik concept developed during the compulsory DFI master's course Interactive Technology Design (ITD) during the 2013/2014 academic year at the faculty of IDE at the Delft University of Technology. Bangerik is an interactive free-flowing game that encourages children to be rebellious in a playful context. It consisted of a wearable worn on the wrist, where the goal of the game to raise their opponent's heart rate by scaring them and then steal their lives by tapping their wristband.

The project is broken down into four distinct phases: *Understand, Ideate, Make and Evaluate.*

Understand:

The "understand" phase was an immersion into the terminology behind the assignment through literature, an investigation of the original concept, online research of current rebellious concepts and potential technology that could be integrated into the final design to be tested at the end of the project. A definition of rebellious play was created and defined as "Where children can actively challenge what is in place and explore their behavioural boundaries, without having to face or endure any serious or lasting consequences" This definition accompanied by a model of rebellious play was used to support the start of the ideate phase. The phase concluded with the establishment of research gaps to be investigated during the next stage of the project.

Ideate:

The "ideate" phase consisted of 2 iterative design loops to find information that could not be obtained from traditional research methods such as literature reviews and interviews. Ideation focussed on the following research gaps, with prototypes created for each aspect and tested with children at a local school:

- How to play tag with Bangerik?
- How to attach something to the body?
- Where to place the tagging locations on the upper body?
- How to raise and lower heart rate during play and should this aspect remain in aspect?

The video data from the testing sessions were analysed with the following conclusions established:

- The upper arms and chest are the most suitable tagging locations on the upper body.
- A garment is best to accommodate the tagging areas on the upper body.
- The heart rate aspect was a vital element and should be integrated into the final design.
- Feedback should be integrated into the final design to indicate when the players the heart rate is high and when they have lost a life.

Make:

The "make" phase consisted of finalising the concept design and establishing aspects to be examined during the pilot study. Aesthetics, prototype behaviour and functions were finalised.

From this point onwards the Bangerik concept evolved into the X-eo concept, a wearable garment tag game that offers the children the opportunities to steal lives from each other by raising other player's heart rate. The tagging, heart rate and visual behaviour aspects of the concept were selected to be embodied into minimal viable prototypes for the pilot study.

Evaluate:

The "evaluate" phase brought a close to the project with the prototypes being tested during the pilot study. The main focus for the pilot was whether the prototype provoked the occurrence of rebellious play behaviour and recommendations for design and research activities with the prototypes in the future. The following sub-questions were operationalised to determine conclusions to the overriding research questions:

- What strategies do the children implement during gameplay and are they rebellious?
- Do the children understand the visual feedback when their heart rate is high, when their lives are stolen, when they are out of the game and when their lives are reviving?

A hierarchy of rules framework was created, so rebellious tendencies through the children's strategies could be identified and classified based on the rules they violated.

In conclusion, rebellious behaviour was present during the testing session with all rules within the hierarchy framework being violated, with contextual and societal rules being the most popular. However it cannot be defined whether these behaviours were directly provoked due to the prototype, the context or the motivational state the children were in before completing the test. The hierarchy framework was a useful tool for classifying rebellious play behaviour. The report concludes with an evaluation of the research methodology applied, research & design recommendations and reflections with regards to conducting future research with the X-eo concept and on rebellious play behaviour.

Acknowledgements

First of all, I would like to thank my supervisory team. Like most things in life, it's about the team you have behind you and I can say I had a great one behind me in Mathieu and Anna. I really enjoyed your company and contributions during the project. You were so approachable and made the project run smoother from my perspective. Our encounters and conversations were never boring and were most enjoyable, filled with interesting discussions, good critic, advice and laughter. I for one will sorely miss them.

I would like to thank Aadjan van der Helm and the ID-Studio lab members for letting me work in their environment over the last few months. I can honestly say I could not have had come across a sounder group of people and I wish all of you continued success with your research.

I would like to express my gratitude to Jessica Lanzafame and her class at the International School Delft for allowing me to test prototypes with them over the course of the project. It was thoroughly enjoyable working with the children, providing me with a lot of interesting insights and laughter. I am sure they will all have bright futures ahead of them!

A big thanks to Richard Bekking, for assisting with prototyping throughout the project. Thanks for your patience, support and free supply of coffee. You are just a wizard and a great problem solver! Nothing was impossible for you to troubleshoot. I learned so much from you, not just about programming and electronics, but life in general and it was a pleasure to pick at your mind throughout my project.

To Lieselotte van Leuwen, thanks for taking the time out of your busy schedule, to help me understand rebellious play better. Our brief encounter on Skype provided a useful outcome for the pilot study, and I really appreciate your contribution.

To my Dutch and international crew, (I'm not going to mention names, ye know who ye are) thanks for providing me with so many fantastic memories over the last 2 and half years in and outside of IO. I certainly won't forget them. Tim and Alice, I was grateful to have ye both at my side and providing me with great support, advice and motivation during the project.

A special mention to the boys of "The Brigade" for keeping me sane during the course of the project, providing me with enjoyable relaxing activities to unwind. I am looking forward to spending more time with all of ye.

To the members of the Den Haag Gaelic Athletic Association, thanks for keeping an eye on me over the last few months, and providing me an outlet to forget about my thesis for a while.

To my "Wexford-Delft support network" Matty and Eimear, thanks for keeping my spirits high, tea supply flowing and my belly full over the last few months. I am grateful for your support throughout all my time in Delft.

Most importantly, I want to express my gratitude to my parents. Thanks for your approval and letting me come back "huis" to Delft to obtain a masters degree. You might have been 800 kilometres away for the best part of nearly 3 years, but your belief and continuous support got me there in the end. Thanks for your unconditional love & support. I hope this will make you proud.

Table of Contents

01 Introduction

1.1 Design Brief

The original “Bangerik” concept was developed during the semester-long compulsory master's course Interactive Technology Design (ITD) during the 2013/2014 academic year at the faculty of Industrial Design Engineering (IDE) at the Delft University of Technology.

The project was completed in collaboration with the European Union wide project, ProFit, whose primary goal is to “ stimulate sport and play innovation and business creation”. A network of FieldLabs was established across Europe to do so, and fortunately, Delft was a chosen location. It allowed citizens to engage in physical play that serves as research and development centres for future sports and play innovations. The Delft FieldLab served as the primary context for this ITD Project, where the given assignment was to create a tool for social and physically active play under the theme of “Rebellious Play”. This theme obtains its play value from the balance of rebellious and conformism states, making rules and then ultimately breaking them. A more in-depth summary of this theme is highlighted in 2.5.

Bangerik was one of the outcomes of the ITD course under this theme. Bangerik is a free-flowing interactive game embodied through a wristband that encourages children to be rebellious in a playful context. The primary goal of the game is to “steal” each other‘s lives by raising your opponent‘s heartbeat by scaring them, being mischievous or by any other means necessary and then tapping their wristband to successfully “steal” their life. A more detailed account of the concept is found in section (2.6.1).

Even though Bangerik was deemed a success by its previous creators, several doubts remained around the concept. Positive views and ratings were received on Bangerik provoking rebellious play. However much of their assumptions were based on previous iterations of the prototype as the final prototype unfortunately did not undergo the final user test of the course. This halted the possibility to conduct further research with Bangerik in the future.

The project was undertaken in the ITD course, aimed at an iterative approach focused on interactive prototyping, where behavioural aspects were neglected throughout the project. Therefore several of the design decisions and elements of the concept remain questionable. These decisions and elements are discussed in 2.6.3

Also due to the nature of the ITD course, thorough research was not an immediate requirement for the course, meaning research activities were not rigorously prepared or executed. The method of documenting research findings in the course was ad-hoc in their nature and did not require an in-depth report but rather a series of statement cards containing the most valuable insights. Hence, very little thorough documentation of the process, testing sessions, findings and outcome of the project exists. Also, no in-depth analysis was subsequently conducted of the actual play behaviour that revolved around the concept.

Rebellious play, as we currently know it, is still a relatively young and new concept within the domain of play and design. This project was one of a few student projects accompanied by a few master theses and academic journal papers conducted and researched on the phenomenon. However, there has been no definite conclusion as of yet, whether rebellious play can be promoted and supported through the medium of design.

Due to the reasons outlined above, Mathieu Gielen, assistant professor in Design for children’s play, initiated the following graduation assignment. It raised the need to further build upon the previous work conducted to redevelop the Bangerik concept and perform a thorough, documented research on the behaviour provoked by it.

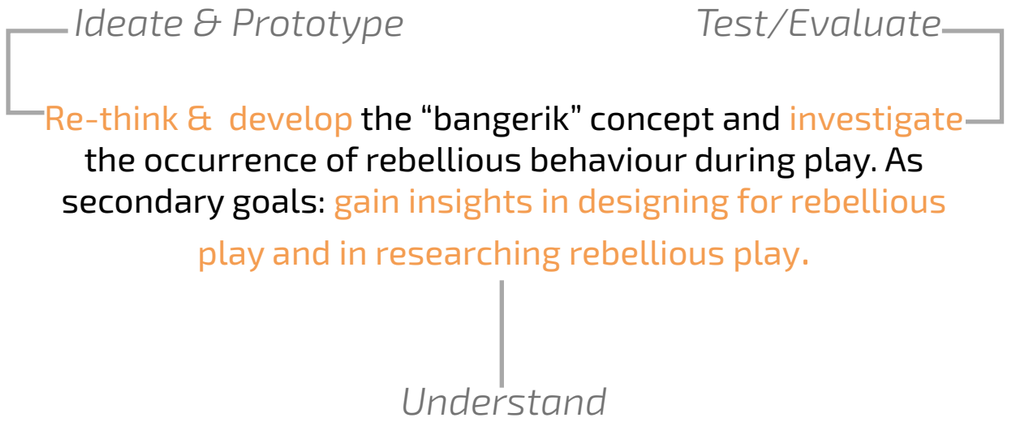


Figure 1.1 : Project breakdown

The project assignment can be divided into two parts and are as follows:

A.)Rethink & develop the Bangerik concept to create a test worthy prototype for the context.

B.) Investigate and study the occurrence of rebellious play behaviour during play.

The first goal of the project is to develop a test worthy prototype. In order to do so, an acquaintance with rebellious behaviour and play terminology is required, through literature reviews.

The second goal of the project is to create a pilot study to investigate the occurrence of rebellious play behaviour provoked by the prototype. Further knowledge of behaviour research and operationalisation will be required to do so.

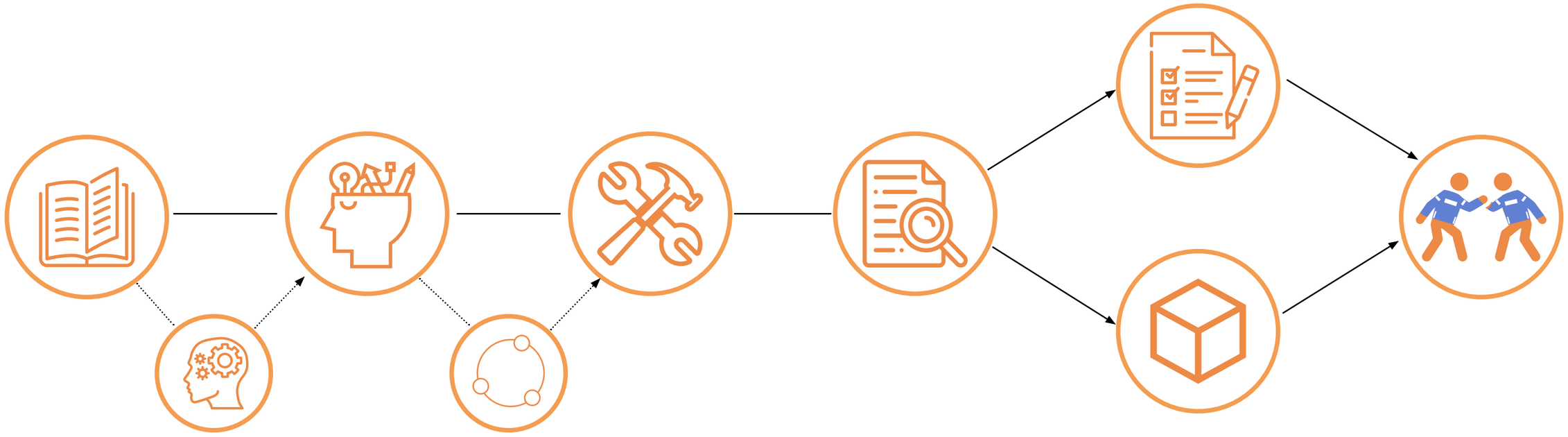


Figure 1.2 : Project approach

1.2 Project approach

The project approach can be broken down into four distinct phases that intertwine research and design activities throughout duration of the project. The phases are as follows and as highlighted in figure 1.2 : *Understand*, *Ideate*, *Make and Evaluate*.

Understand:
The project begins with a thorough literature research revolving around the core concepts of the project, “rebellious behaviour” and “Play”. The goal of this phase is to get familiar with the terminology required and gain insights on the original Bangerik concept and investigate suitable technology that would further enrich the design process towards the redevelopment of the original concept

Ideate:

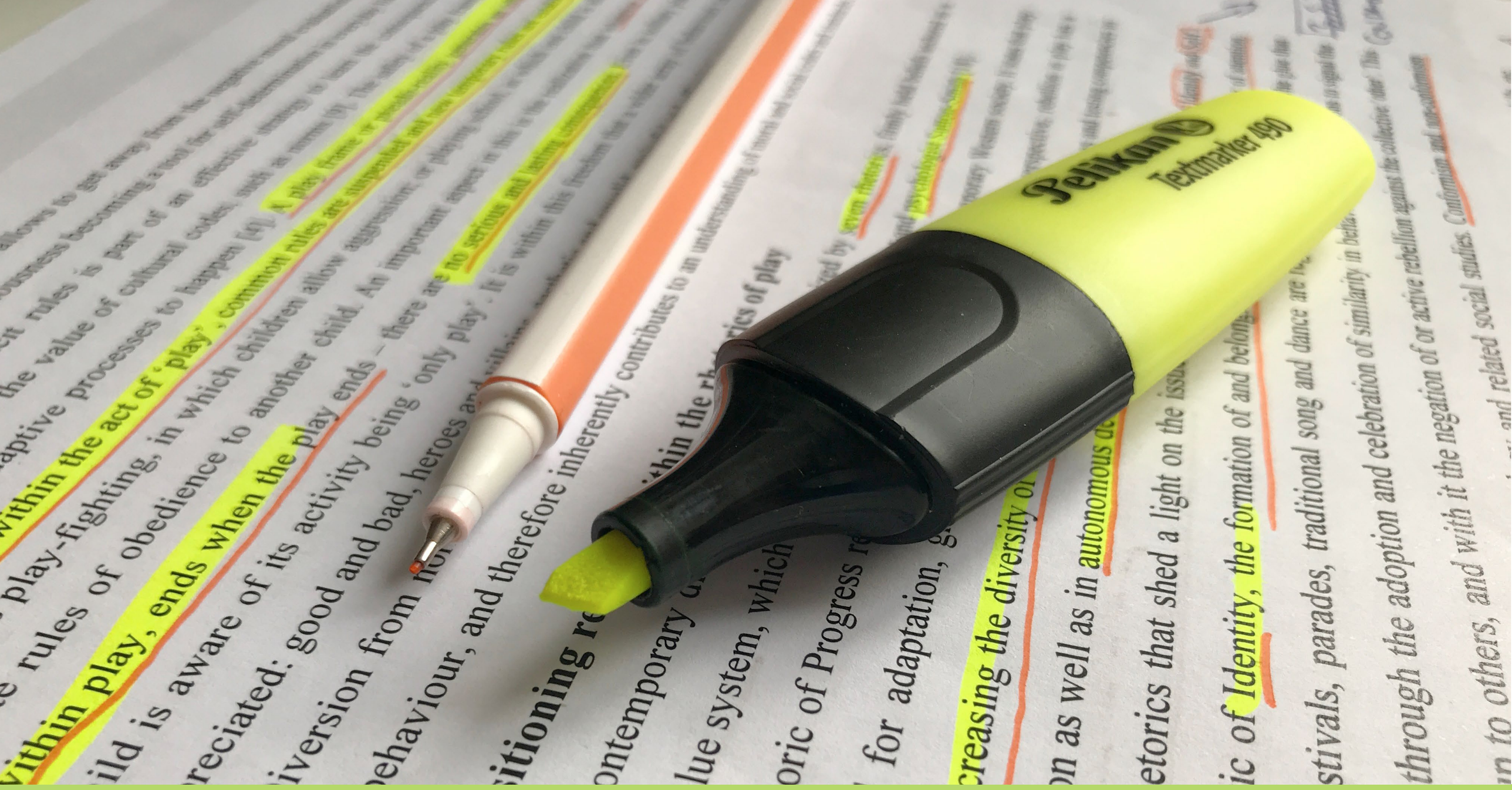
The purpose of these testing sessions is to obtain information on aspects that remained unclear from the understand phase that could not be gathered through a literature review or other means. The knowledge gained from this phase will be translated into the criteria for the final design of the prototype, to conduct the pilot study.

Make:

The X-eo concept is thought out and detailed, where it shall be programmed and embodied to an experiential level for thorough testing in the field.

Evaluation:

A qualitative pilot study is prepared and conducted after continuously getting acquainted with behaviour research techniques acquired throughout the duration of the project. The prototype is brought into the field for testing and the obtained insights shall be analysed and evaluated towards a final conclusion of whether rebellious play was provoked and supported through the design. Formal deliverables such as the final report, pilot study and prototype are concluded and finalized accompanied by further recommendations for conducting future design and research activities on rebellious play.



02

Understand

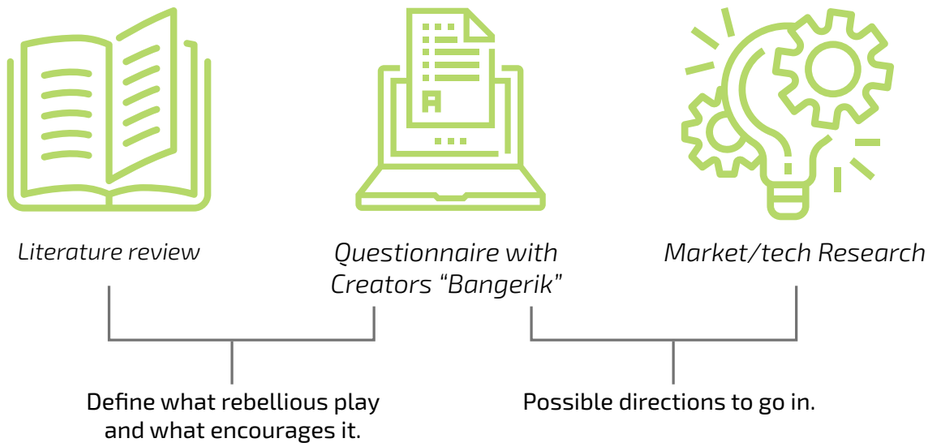


Figure 2.1 : Overview and expected outcomes of the Understand phase.

2.1 Overview

The first 3- 4 weeks of the project are an immersion into the terminology (of rebelliousness and play) behind the assignment, the original concept, current rebellious concepts and potential technology that could be integrated into the final design. (See fig 2.1).

A literature review was undertaken to gather information on potential factors required to cater for rebellious play. Interviews and questionnaires were conducted with the original Bangerik team members to gain an understanding of their motives, thinking and aspirations of the concept. The obtained insights were clustered, so a personal definition of rebellious play could be defined.

Brief research on rebellious concepts was also conducted to investigate what is currently available to provoke this behaviour and to create a comparison to the original Bangerik concept. Furthermore, this was accompanied by an online investigation of suitable technology that could be implemented during the "make" phase of the project.

2.2 Goals

During this phase of the project, it was essential to learn and grasp what rebellion and play entail, as this is the core of the phenomenon being researched. By doing so a better understanding and grip of the assignment is acquired by making a personal definition of rebellious play that could be utilised and designed for during the project. Furthermore, an evaluation of the current Bangerik concept is made to set the scope for potential redevelopment and improvements.

2.3 Rebellious, what is it?

Rebellion, in general, is a hard term to define, as its connotations are extremely broad. When one thinks of rebellious a lot of ideas come to mind, whether it is in respect to political and social uprisings that have appeared in the media in recent years, as an "act defying lawful authority, resisting control and conversion." However, rebellious behaviour depicts itself on many different levels, varying from the examples described above, to a more relatable example of a child not complying with their parent's wishes.

As broad as the term is, several psychologists have attempted to summarise their thoughts on this behaviour. In general, rebellion can be regarded as " going against social norms" and "social risk taking" (Apter,et al 1976). The majority of these norms embody themselves in the form of social rules, institutional rules and laws. We encounter these on a daily basis in our lives when we encounter a dilemma, where we either comply or rebel against it. (Gielen, 2018)

In some cases, rebellious behaviour is increasingly getting recognised as a response to "Coping with social influences" (Apter.1976). However Apter, states rebelliousness as

" wanting or feeling compelled to do something contrary to that required by some external agency". (Apter,1982).

Rebellion is regarded to be one of the cores of human behaviour. However, where does this urge to behave in such a manner derive from? Reversal theory suggests that these motivational states need to be experienced to maintain physiological well-being. It is normal for people to transition between both conformists and negativistic states continuously. Reversal theory is further discussed in section 2.5.3.

Furthermore rebellion asserts itself through 2 forms in pro-active and reactive rebellion. Proactive refers to doing something for the sake of immediate pleasure or excitement. Reactive rebellion, on the other hand, is a reaction to interpersonal disappointment or frustration (McDermott, 1988).

2.4 Play, what is it?

Similar to rebellion, play is also a hard term to quantify in a single statement. Several child psychologists have tried to stamp their mark on the phenomena and have contributed to what this term could potentially be. To this day there is still no recognised definition but rather a set of characteristics that revolve around the term for which it can be universally recognised and referred to.

Play has a psychological function often described as a basic human need and a function of human development, (Eberle, 2014). It is a function that serves to meet "the wishes and needs of the child" and cultivates the

"creation of a pseudo-reality" (Van der Bijl, 2000)

that "allows them to inhabit a distinctive world of their own making". Play is aimless but rather process led with no particular outcome expected (De Valk, et al 2013) and is viewed as a way of relaxation for both adults and children alike to escape the pressures of everyday life (Valentine & McKendrick. 1997).

2.5 So what is rebellious play?

Rebellious play, as we know it is a relatively new concept in the world of play and child psychology. As expected it has not formally received a proper definition. For the sake of convenience; a personal definition of the phenomena was derived to be used for the duration of the project to assist in the research and design process. The obtained definitions for both rebelliousness and play were analysed, with the most suitable definition for both terms used as a basis to create a personal definition. Furthermore, the definitions of both Apter (1982) and Van der Bijl (2000) were preferred as seen in figure 2.2 below. These definitions were chosen based on their reference to other rebellious play related literature.

With these terms in mind, rebellious play can be defined as:

“Where children can actively challenge what is in place and explore their behavioural boundaries, without having to face or endure any serious or lasting consequences”.(Kent, 2019).

Play is a safe place for children to explore the full array of their behaviours and the consequences that arrive with it. Hence it is a suitable place to experiment with rebellious behaviour in a pseudo-reality free from parental supervision and expectations, where children are allowed to develop their personality and social skills. (Gielen, 2013).

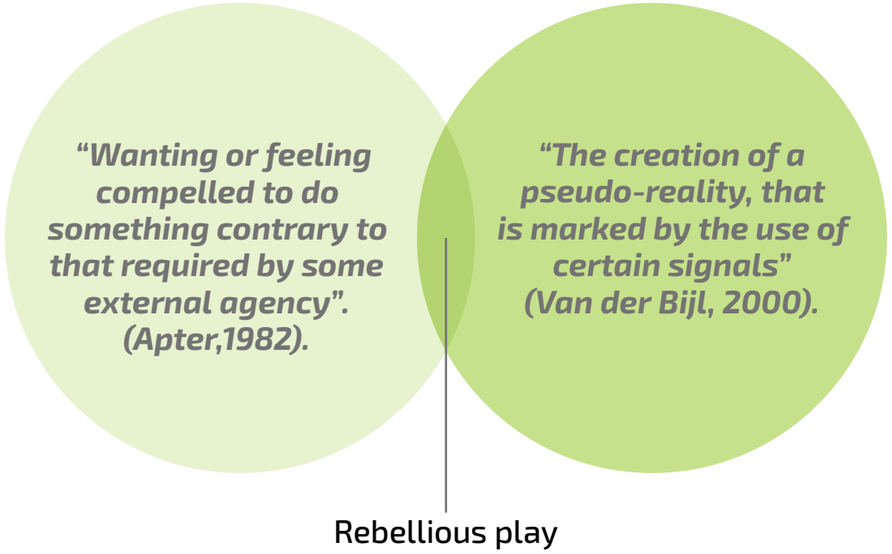


Figure 2.2 : Chosen rebellious and play definitions to formulate rebellious play definition.

2.5.1 Model for rebellious play

For the phenomena to occur, certain conditions should align and be provoked for it to happen. As the definition has already been discussed in 2.5, the rest of the factors outlined in figure 2.3 shall be further discussed in a clockwise manner.

Figure 2.3 : Model for rebellious behaviour

2.5.2 Motivation

The motivation to participate and engage in rebellious behaviour of any sort comes in many forms and can also be applied within the phenomenon of rebellious play. These factors are outlined in figure 2.4 below and shall be discussed in further detail.

Figure 2.4 : Motivations to participate in rebellious behaviour.

Competition

Most children in their manner are naturally competitive and will do anything in their power to achieve the top spot or be the winner. In the case of competition, it allows for cheating and bending of the rules to their favour. They don't care how they win, as longs as he/she comes out on top. (Luijpers, 2014)

Frustration

Frustration can be a consistent driving factor to partake in rebellious behaviour. It holds the ability to provoke a reaction of some sort in the case of dealing with injustices, restrictions, shortcomings and failures.

Enhance reputation

Acts of rebellion can enhance reputations and provide for the exertion of dominance and control over a group and their environment. In the case of a child, performing a rebellious act may allow them to gain acknowledgement and to set themselves apart from their peers, hence enhancing their popularity, reputation and personal image. (Luijpers 2014) (Gielen 2013).

Emotional arousal of forbidden act

There is often a thrill and excitement to engage in something edgy and frowned upon by others or society in general. Quite often there is an emotional arousal caused by the sheer forbidden nature of the act (Apter, 2007).In the case of a child, this could range from eating sweets without getting permission to do so. Furthermore, engagement in these acts embody themselves as responses to boredom and frustration, or in some cases as ways of experimentation, adventure, escape or just to seek connections with others. (Mathye, 2004). Motivations for engaging in risky behaviours vary. Some engage in these behaviours as a response to boredom, frustration, pain, powerlessness and lack of hope for change. Some behaviours are engaged in as a way of experimentation, adventure, escape or connection with others

Emotional arousal of forbidden act

Staying in a mindset of any sort for an extended period of time is not beneficial. According to Apter, the same can be applied to prolonged periods of conformism. Adhering to a system, rules and structures after a while may become banal, restricting and frustrating after a while. Sometimes there is not a particular reason for someone to act or engage in rebellious behaviour; it just happens and more than often involves searching for a reason to do so. (Apter, 2007) (Gielen, 2013).

2.5.3 Conditions

Several conditions must be met for the occurrence of rebellious play.

In principle for rebellion to occur, there are two things required: something to rebel against (e.g., rule, person, system, etc.) and audience of witnesses to acknowledge it. (Sutton-Smith,1997) (Gielen,2013).

According to Reversal theory (Apter, 2007a), rebellious urges occur depending on the individuals current mind state, the situation they are in and the possibilities for action they have at hand. For example in a playful state of mind, excitement is increased and rules are perhaps broken just for fun. Of course this and the possibilities that follow will vary per situation the individual find themselves in, as different rules and authorities may apply depending on the context, (e.g. home, schools, public spaces, etc.).

Building from reversal theory, the rebellious triggers mentioned above in figure 2.6 can be further supported by the factors influencing these reversals between conformist and rebellious states. They are as follows: *satiation, contingency and frustration*.

Satiation revolves around, as this refers to the amount of time one spends in a certain motivational state. As previously mentioned in 2.5.2, if we stay too long in one state of mind there could be the urge to switch to the other for no particular reason, as is often the case of children conforming to the demands of parents to focus on given tasks.

Contingency revolves around the situation one finds themselves during requests or opportunities for action, which can very much influence reversals between both states. In the case of the child, it is where they don't have the clear affordance to play. For example at an airport or on a train where they are encouraged not to play, but there are plenty of artefacts in the context that invites them to explore and do so.

Frustration drives reversal between these states as people adhered to the rules, systems, but ultimately affected their possibilities to turn things to their advantage. An example of this would be a child losing a game and realises that another child has negated the rules and gained a massive advantage, which is making other competitors lose.

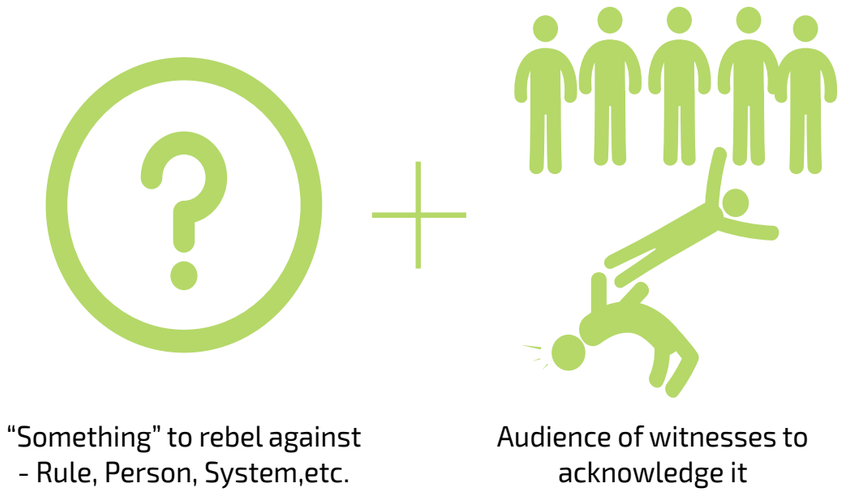


Figure 2.5 : Chosen rebellious and play definitions to formulate rebellious play

Figure 2.6 : Potential triggers for switching between rebellion and conformism.

2.5.4 Maintaining

With the conditions previously outlined, the question that now remains is how to maintain and cultivate rebellious play?

As previously mentioned in 2.5 for the definition of rebellious play, it allows for the exploration of behavioural boundaries without any immediate or long last consequences. Children may not participate in rebelliousness if they know there is going to be some sort of punishment involved. There has to be no such enduring consequences outside of the play frame, however in-game consequences amongst peers still remain. (Luijpers, 2014).

Punishment may be inflicted on children if their parents or guardians interpret their behaviour during play as morally and socially unacceptable. Rebellious play preferably has to be free of adult supervision and influences, to ensure that the child gets the freedom to experiment with their behavioural boundaries. (Gielen, 2013)

Regular spells of dilemmas should be integrated into the play frame to ensure that there is a continuous amount of choices to be made between conforming and rebelling. (Gielen, 2018)

As well as being a primary factor for motivation and a condition for rebellious play, frustration also plays a role in prolonging the phenomena. Bouts of frustration throughout the play frame (e.g. losing a life in a game, others cheating) provokes a reaction that potentially influences the child to take matters into their own hands and retaliate against the cause in a rebellious fashion.

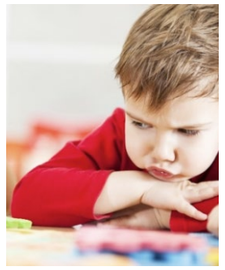
No consequences	Free of supervision	Frustration	Continuous Dilemmas
			
Children will not partake in rebelliousness if they know there is going to be some sort of punishment involved. There is no enduring consequences outside the play frame but there is in game consequence.	Gives the child freedom to do stuff that's usually not acceptable: *"Mum is not here so I"m going to go sneak up on him and scream in his face".*	From the child's perspective getting a life stolen in a game. It turns into a motivation to do something about it: *"Oh no! He just stole my life! I'm going to get it back somehow!"*	There has to be a continuous amount of choices to be made between conforming or rebelling. *"Am I just going to keep low or be really cheeky and do this?"*

Figure 2.7 : Chosen rebellious and play definitions to formulate rebellious play definition.

2.5.5 Benefits

Why would one want to engage in such behaviour? Rebellious behaviour has been documented to prove benefits in personal development to those who partake in it. Some of the benefits are outlined in figure 2.8 below.

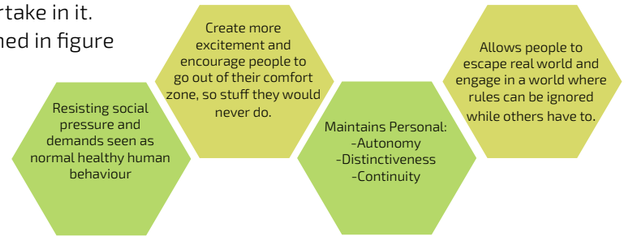


Figure 2.8 : Benefits of rebellious behaviour.

2.5.6 Boundaries

Even though there are no immediate or serious consequences as such, rebellious play does have boundaries and limitations.

Rules themselves are enforced boundaries on the play. They are put in place as guidelines and boundaries to direct the play, however they can be place be challenged and broken.

Safety as previously mentioned, is crucial to play and the pseudo-reality of the play frame. Inflicting physical hurt or harm on each other breaks the boundaries of the safe haven of the play frame, with players potentially leaving the pseudo reality with real consequences to apprehend. This factor varies from child to child, with some having a higher threshold than others. Likewise being forced to do something against your will, also affects a child's sense of content and safety.

Rules	Inflicting harm or hurt	Compulsion
		
Rules restricting the game play.	When you hurt someone you are outside the play-frame	Being forced to do something against your own will.

Figure 2.9 : Boundaries and limitations to rebellious play

2.5.7 Conclusions

The literature research element of the understand phase brought about the following conclusions.

Rebellion can be defined as “Wanting or feeling compelled to do something contrary to that required by some external agency” (Apter, 1982).

Play is a process led, psychological function that can be defined as “creation of a pseudo-reality marked by certain signals.

Rebellious play is defined as “Where children can actively challenge what’s in place and explore their behavioural boundaries, without having to face or endure any serious or lasting consequences”.

Competition, frustration, enhanced reputation, emotional arousal of forbidden acts and prolonged conformism are all potential motivations to provoke rebellious behaviour.

The key considerations for maintaining rebellious play are no consequences, no adult supervision, frustration and spells of continuous dilemmas between conforming and rebelling.

2.6 Understanding the original Bangerik

As there was limited documentation available regarding Bangerik, a questionnaire was developed and sent to the original team members who worked on the concept during the ITD course. The aim was to get insights on the functions of the concept, the technology implemented and preliminary insights they gathered from their testing sessions. The full responses can be found in appendices B.

2.6.1 Bangerik?

As previously mentioned in 1.1, Bangerik is an interactive free-flowing game that encourages children to be rebellious in a playful context. Namely, the possibilities for children to be creative during play and come up with strategies to scare their opponents in order to increase their heartbeats in order to steal their lives. The prototype that ensued from several iterations was a wearable in the form of a wristband. This was primarily decided for the sake of logic in terms of prototyping due to the limited time available during the ITD course.

The basic form of the concept consisted of cuboid and an interface integrated with several embedded LEDs, a conductive touchpad and heartbeat sensor (see figure 2.10).

The primary goal of the game is to "steal" each other's lives by raising your opponent's heartbeat by scaring them, being rebellious, mischievous or by any other means necessary. During play, this confronted the players with conflicting decisions to make: to remain stationary and still (be safe) or becoming physically active and endangering their own situation. The act of stealing physically takes place when they tap/tag their opponent's wristband when their heart rate is sufficiently high enough. The opponent's life would be transferred to the other player, and the process continues until their three lives have been exhausted, hence putting them permanently out of the game.

The thinking behind the game mechanics

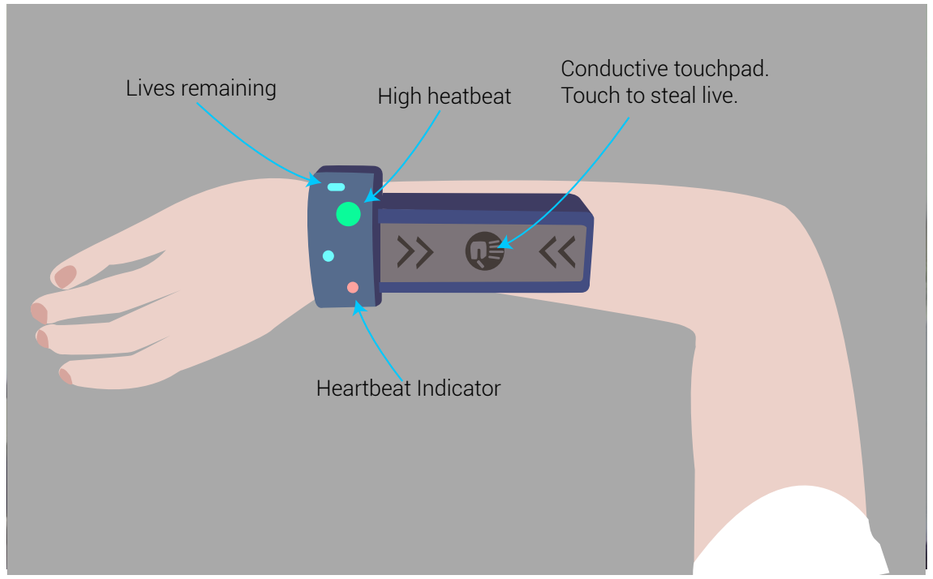


Figure 2.10 : Bangerik concept

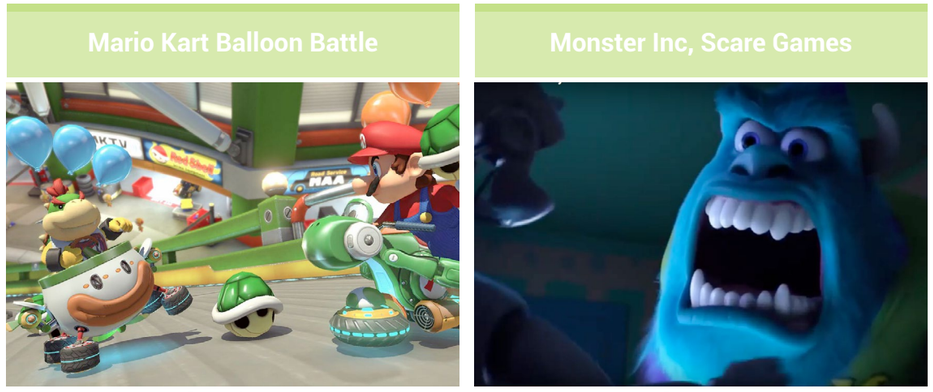


Figure 2.11 : Bangerik influences: (Left) Mario Kart- Balloon battle mode, (Right) Scare games from Monsters Inc, University.

was primarily influenced by popular game and movie titles, Mario Kart and Monsters University. The stealing element was influenced by the balloon battle mode within Mario Kart, and the scaring aspect from Monsters Inc. respectively.

An Arduino Uno handled the internal operations of the game. This was accompanied by blue LED's to indicate lives remaining, a red led to show current heartbeat and a large green led to indicate when a players heartbeat was high enough for a life to be stolen by an opponent. A heartbeat sensor was attached to their player's index finger to measure their pulse. A capacitive plate was the central touch point for players throughout the game, and when this was activated a life would be transferred wireless to the other device via an X-Bee module.

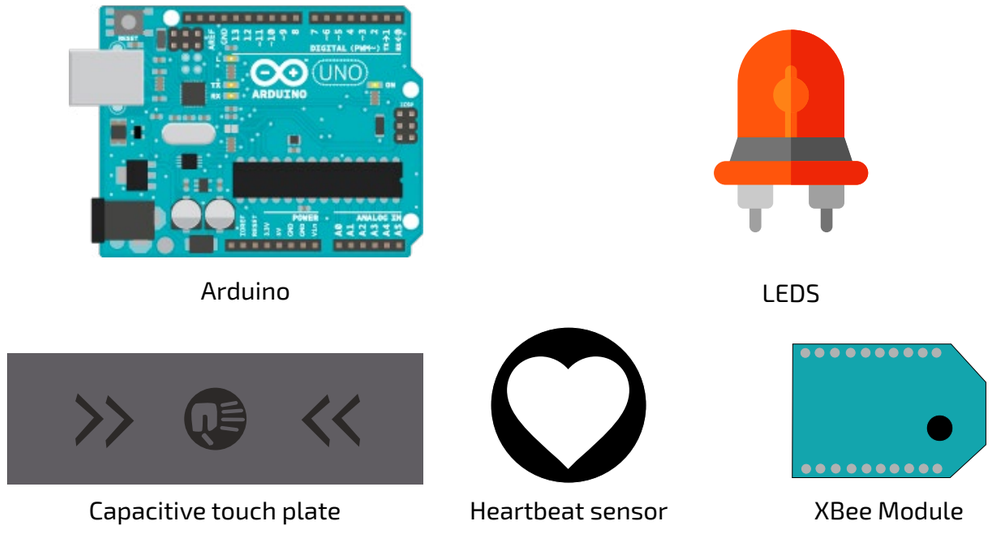


Figure 2.12 : Components within the Bangerik concept

2.6.2 Initial tests with Bangerik

The Bangerik concept and its previous iterations were tested at the kindergarten of the participating schools for the course and at a pre-defined set-up consisting of a cardboard fort in a studio at faculty of industrial design during the final test for the course. Even though documented results from testing was limited or non-existent, the original team members provided some preliminary insights from their testing sessions and they are as follows:

- They left the envisioned play entirely free and open to allow the children to be creative to come up with their own strategies and tactics to raise each other heartbeats.

- -The context heavily influenced how the children played the game (see figure 2.13). At the school testing with the kindergarten, the game became more tag orientated due to the amount of space available to them to move and run around in. While more enclosed spaces such as the cardboard fort encouraged more hiding and scaring.

- The children were utilising mindfulness techniques to ensure that their heartbeat was kept low to ensure that their lives could be stolen.

- Even though the final prototype did not withstand its final user test, the team believed that the concept has the potential to achieve rebellious play based on earlier iterations of the prototype.

Kindergarten School

Cardboard castle at IO

Figure 2.13 : Testing contexts with bangerik during ITD course.

2.6.3 Identifying opportunities for Bangerik

The insights gained from the questionnaire were analysed and brought forward into a swot analysis to further identify the strengths and weaknesses of Bangerik, to investigate whether the concept in it's current form is the best option going forward or at least provide early indications for initial ideation.

Strengths

Game is free & open: By limiting the number of rules in the games, it opens up many possibilities for the children, it should allow the children to explore their behavioural boundaries in a relatively safe environment. There is nothing right or wrong as such in the game. It stimulates the children to get creative to actively challenge the single rule that's in place.

Stealing as a motive: As previously mentioned in 2.5.2 in the report, there is something compelling in being allowed to attempt and participate in something that's not normally permitted or accepted by society in general.

Creative strategies to raise others heartbeats and control their own: Bar the apparent benefits of participating in cardiovascular exercise, the children had to get creative in raising others heartbeats whether this was by physical or subtle means. (E.g. chasing, manipulating their body, scaring, etc.), as this was the key to opening stealing opportunities in the game. Furthermore, by controlling their heartbeats to be low, it allowed them to reduce the possibilities of their lives getting stolen and potentially staying in the game for a more extended period.

Weaknesses

The heartbeat sensor: Several issues came from the heartbeat sensor integrated into the prototype. Even though the heartbeat aspect was central to the game, the sensor was unreliable at detecting the pulse accurately due to moisture (sweat, rain, etc.). The placement of the sensor was limited to the index finger due to technical capacities of the sensor and preferably required the user not to be active while taking measurements.

The size of the prototype: The prototype was quite large and cumbersome in comparison to a child's lower arm, and made moving slightly awkward during gameplay.

The positioning of the prototype: Placing the prototype on the wrist was the most convenient at the time. However, it offered limited interaction and tagging/stealing opportunities during gameplay. This was due to the challenging nature of trying to tag a single target, where the children had multiple strategies of protecting and preventing it from being tagging.

Game mechanics: The game provided the players with three lives at the start, however when their lives expired they were permanently out of the game with no possibility to participate again.

Opportunities

Utilise other body parts for the game: By positioning target area on other (or multiple) body parts, it should open up opportunities for tagging within the game.

Adjusting game mechanics for equal participation: By integrating "time outs" or "Sin Bins" as opposed to being permanently out of the game, potentially allows children to rebelliously regain their live status and allows them to continuously participate in the game.

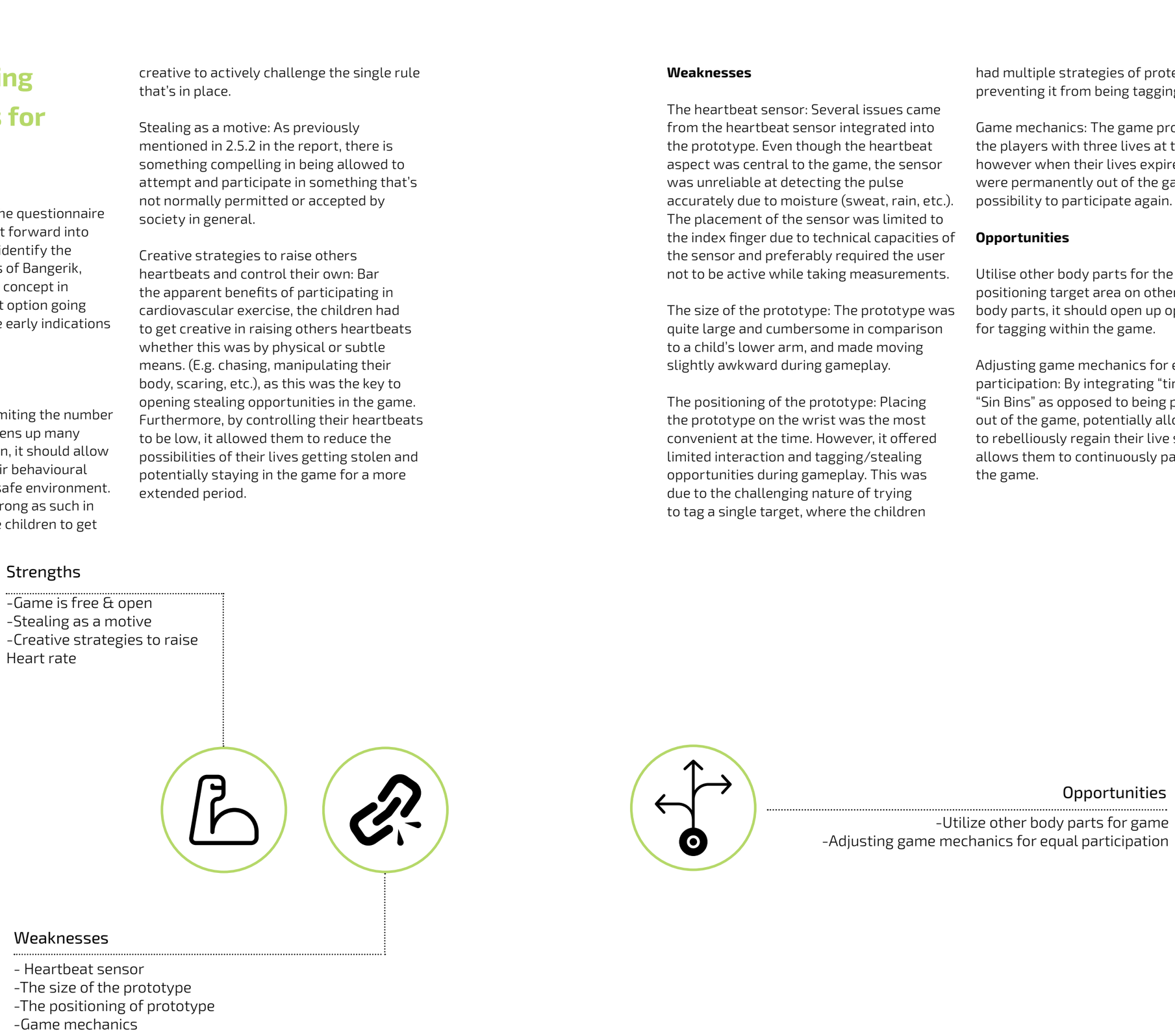


Figure 2.14 : Testing contexts with bangerik during ITD course.

2.6.4 Bangerik investigation conclusions

From this investigation, it became clear that Bangerik is quite a simple game in its nature terms of its dynamics. It held dynamics and similarities to that of traditional tag/ chase schoolyard games. There is more to concept than just stealing each other's lives and opportunities lie in strategies of trying to protect your lives by lowering ones heartbeat. It catered for the children to come up with a range of strategies to do so.

Furthermore the concept offered the children the opportunity to participate and experiment in usually forbidden acts in a relatively safe manner. However, there is not an accurate consensus on the rebellious potential of the concept.

Opportunities were presented regarding the redesign of the concept in terms of form technology, game dynamics and utilizing other body parts. A selection of these aspects are further investigated in Ideate, chapter 3.

Furthermore the influence the chosen testing context has on the occurring play was highlighted, and should be taken into consideration for future testing sessions during the ideate phase and the pilot study.

2.7 Online research

The previous chapter brought about a general understanding of the Bangerik concept. This raised curiosity of other existing rebellious concepts for children, technology and wearables that are currently available to provide further inspiration for the design process. Online research was conducted to do so.

2.7.1 Current rebellious concepts

There were no genuinely rebellious concepts available, but there was a range of items that held rebellious traits and the spectrum of their rebelliousness as such varied significantly from practical "joke –like" to more realistic situations/scenarios in video games. (See figure 2.15).

As ridiculous as they may seem analogue games such as pie face or don't step in it hold rebellious traits, as you aim to put a pie in your opponents face or alternatively guide your blindfolded opponent to step into foam shaped dog turds.
Fart guns have become popular with children due to the ever grown instalments of "the despicable me" franchise of films. It allows them to trigger and replicate the sound of flatulence in various contexts, which is considered rude and frowned upon by society.

Nerf blasters also hold rebellious traits as they accommodate for war like scenarios without having actual injuries or fatalities, and provides them with role play the children chase and hide from each other in a fantasy world of their own where targets are more socially acceptable. (E.g., zombies, robots, cops & robbers, cowboys & Indians.) (Tietze, 2019).

Similar to what analogue games offer, video games such as The Sims and Fortnite offer players a safe place to contest power and authority structures in place. The opportunity to do things they are not supposed to do is so powerful, as the context they have immersed themselves into seems so realistic. (Sandford & Madill , 2006). The Grand Theft Auto franchise of video games is a prime example of this, where the players can perform robberies, drive-by shootings and murders with the tools at their disposal throughout the game. They can participate in these actions knowing that there are no real consequences to be endured.

In conclusion, none of the items outlined were purposely created for rebellious play. However, they all contain traits previously mentioned throughout section 2.5 with regards to the motivations and conditions to provoke rebellious play. These should be kept in mind during the ideate phase and prototyping phases of the project.

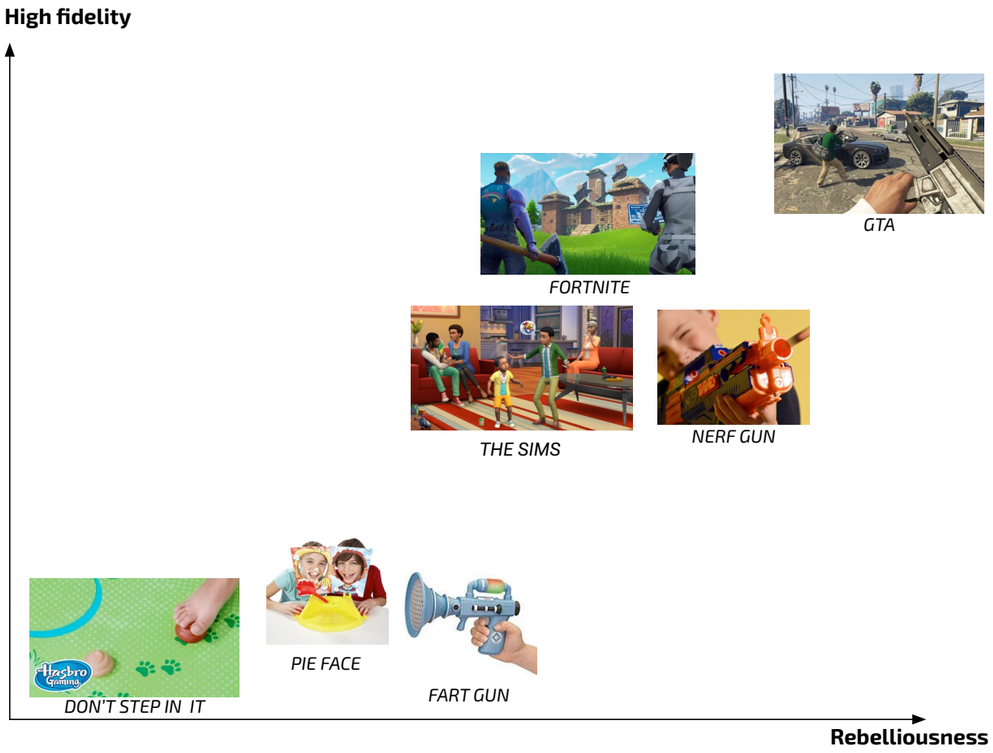


Figure 2.15 : Benchmarked rebellious concepts found through online research.

2.7.2 Wearable variety

As the Bangerik concept took the form of a wearable, it was worthwhile investigating what's available and developing in this field and what's being currently accepted by children in this domain.

Wearables have rapidly evolved from wristband like devices that still prove to be the most popular, followed by forms that capture other parts of the body as seen in figure 2.16. These range from smart watches, heartbeat monitors, earphones, glasses and smart textiles all primarily having an exercise and health-focused purpose.
An array of children wearables have sprung on the market in recent years with a focus on physical activity, child safety and privacy, interactive games such as laser tag, and devices supporting various smartphone apps such as Pokémon Go. (See figure 2.17.) Other applications for children's wearables remain relatively untouched/unscathed due to the connotations they have with increasing smartphone and tablet usage amongst this demographic.

According to Rosales, et al., (2015), wearables are well suited to play as they can cater for natural interactions with a device through physical movement. They can support the natural transition from individual to parallel group activities, which holds potential for the bangerik concept.

In conclusion, wearables are a suitable direction to perform bangeriks functions due to the variety available in terms of body parts they can accommodate and the acceptance of the form through children's smartwatches, trackers and interactive games.

Figure 2.16 : Selection of wearables available to accommodate various parts of the human body.

Figure 2.17 : Selection of children's wearables currently available

2.7.3 Potential technology implementations

Based on the initial investigation of the original concept, most of the technology integrated is open to change. These modifications revolve around the core elements of the heartbeat, tagging and wireless communication of stealing lives between players.

Heartbeat

The heartbeat factor holds a major role in the game as it influences when other players can take lives from each other. The Arduino pulse sensor was integrated within the game and some issues arose with it. Hence other options were sought after for potentially integrating into the project. (See figure 2.18)

Heart rate technology	*Advantages*	*Limitations*
 Pulse sensor	• Arduino pulse sensor is a simple plug and play device. • Runs on similar principles to photoplethysmography • Uses a single green lED and diode to measure blood flow	• Measurements only accurate when person stationary. • Sweat and moisture affects measurements. • Normally placed on ear lobe or index finger
 Pulse /tissue Oximetry	• Measures oxygen in blood-supply/local tissue • Applicable to several body parts: Hand, feet, forehead, chest. • Applied to skin with adhesive.	• Complexity of working with Arduino and other processors • Ethical and protection implications; Requiring to attach to children, removing clothing, etc
 ECG	• Measures electrical activity on skin as heart contracts and blood travels through ventricles. • Applicable to upper body and legs	• Depending on form applied, traditional (cables and wet sensors or non obtrusive (e.g compression sleeve), may have ethical implications for testing.
 Photoplethysmography	• Measures oxygen in blood supply through, green LEDs and infrared LEDs. • Detects amount of blood flowing through skin surface on wrist. • Proven to work in smartwatches	• In medial world= cheap, but for project and budget allocation = Very expensive. • Good fit critical for measurement accuracy. • Wrist most accurate location

Figure 2.18 : Selection of heartbeat measurement options.

Tagging

As tagging and stealing lives is the primary purpose of the concept, it is important to achieve this in a natural fashion that is recognisable to the children.

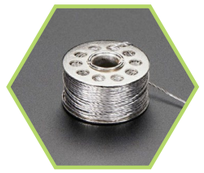
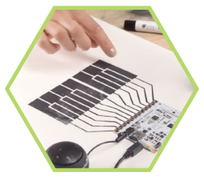
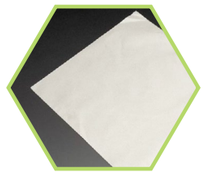
Tagging	*Advantages*	*Limitations*
 Stainless steel conductive thread	• Thread that contains stainless Steel fibres and holds conductive properties. • Extremely touch sensitive depending on resistance when combined with Q-touch sensor.	• Thread is quiet thick and stiff. Hard to sew precisely with it. • Needs to be in constant tension to remain reactive.
 Conductive ink	• Graphite based conductive ink that can be applied to almost any surface and transform them into sensors .compatible with micro-controllers. • Can be screen printed or stencilled into a patterns.	• Water based- may become less reactive unless sealed with acrylic paint or varnish. • Has to be applied in a consistent layer to provide accurate data to micro controller.
 Woven conductive fabric	• Highly conductive woven silver plated nylon fabric , that is easily shaped into desired patterns.	• Extremely rigid and paper like and potentially hard to flex around body parts in large pieces. • In terms of aesthetics, will discolour due to oxidation.
 Pressure sensitive conductive sheet	• Velostat is a pressure sensitive material and incorporated easily into wearables and smart textiles. • Cut pattern into desired shape and discreetly embedded in the desired form.	• Relatively inexpensive and therefore can be inaccurate with gathering data. • Depending on placement and adhesive could be easily damaged.

Figure 2.19 : Selection of tagging component options.

Wireless communication

As the transfer of lives between players is a vital part of the game, a suitable technology needs to be integrated to make the function as seamless as possible during play.

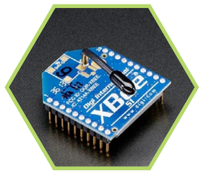
Wireless communication	*Advantages*	*Limitations*
 Bluetooh	• Suitable for exchanging data over short distances using short wave radio frequencies.	• Relatively new technology for open source micro controllers. Limited coding libraries available.
 Xbee	• Xbee is more automation focussed and suitable for transferring and exchanging	• Power consuming

Figure 2.20 : Selection of wireless communication components

Conclusion

In conclusion, there is a wide range of components available to cover the various aspects of the concept. Their pros and cons were outlined, with some components already taken a more favourable position for integration into the concept (see table 1). Furthermore, the components will be determined from the insights obtained from testing during the ideate phase and will be further clarified later in section 4.4.6 of this report.

Component Category	*Selected components*	*Reasoning*
Measuring Heartrate	Pulse sensor/ heart sensor	A photoplethysmography heart rate sensor has a proven record and is integrated in several wearables currently available. The placement of the sensor is flexible, and does not need to be placed on a fixed location on the body to receive an accurate heart rate measurement.
Tagging	Woven conductive fabric	Easily cut to desired shape of tagging location and reduces amount wiring and soldering required to connect them to processing board.
Wireless communication	Bluetooth	Currently the most common means of communication between wireless devices and wearables. This less power consumptive than other options, which is vital if the game will be played over a day long duration.

Table 1 : Selected components from ideate phase to be integrated into the redesign of bangerik.

2.8 Understand conclusions

A vast amount of insights were gathered throughout the understand phase, with regards to rebellious play behaviour, the Bangerik concept, current rebellious trends, wearables and finally potential components for the redeveloped Bangerik concept. By doing so, research gaps were established to address in the ideate phase of the project. The main insights are as follows:

Play is a basic human need and a function of human development and can be defined as the “creation of a pseudo-reality” that allows children “to inhabit a distinctive world of their own making.”

A definition of rebellious play was substantiated for the project and defined as “Where children can actively challenge what is in place and explore their behavioural boundaries without having to face or endure serious any lasting consequences”. Furthermore, the requirements for such phenomena are outlined and should be taken into consideration further in the design process during ideation and creating the final prototype for the pilot study.

Rebellious trends in the marketplace were investigated, with products remaining limited. They held rebellious traits but none were truly rebellious as such.

It became apparent that the Bangerik concept is a simple game in its nature, which aimed to provide the opportunity for children to be rebellious with the strategies they implement to raise each other’s heartbeat and steal each other lives. The analysis has indicated that the following aspects should be optimised in the concept: the heartbeat sensor, size of the prototype, positioning of the prototype on the body, and game dynamics.

Wearables are available in many forms and are well accommodated to fit various parts of the human body. They are accepted by the demographics of children and suited to the interactions of play.

And finally, potential components for the redeveloped concept have been analysed by outlining their advantages and limitation so an informed decision can be made later in the design process.

Furthermore, the following research gaps have been established and shall be investigated further during the ideate phase. (see figure 2.21).

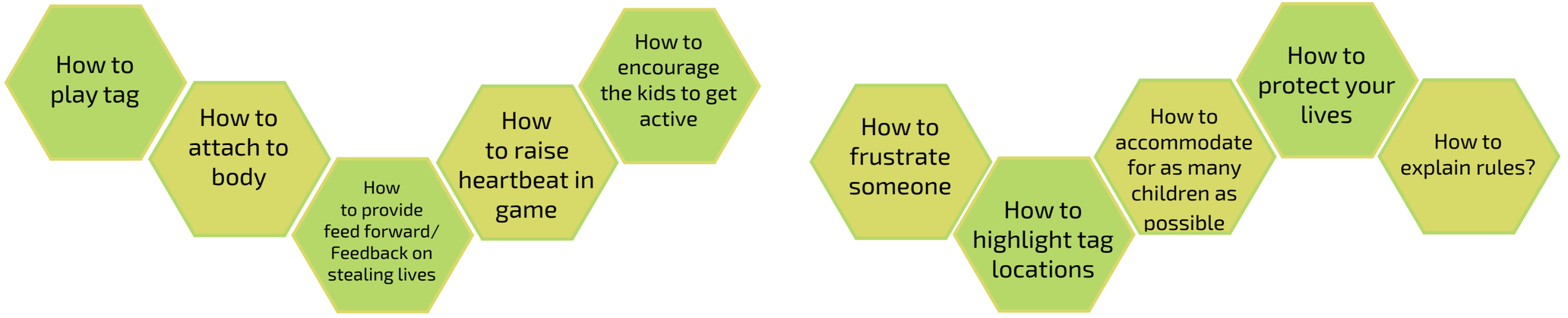
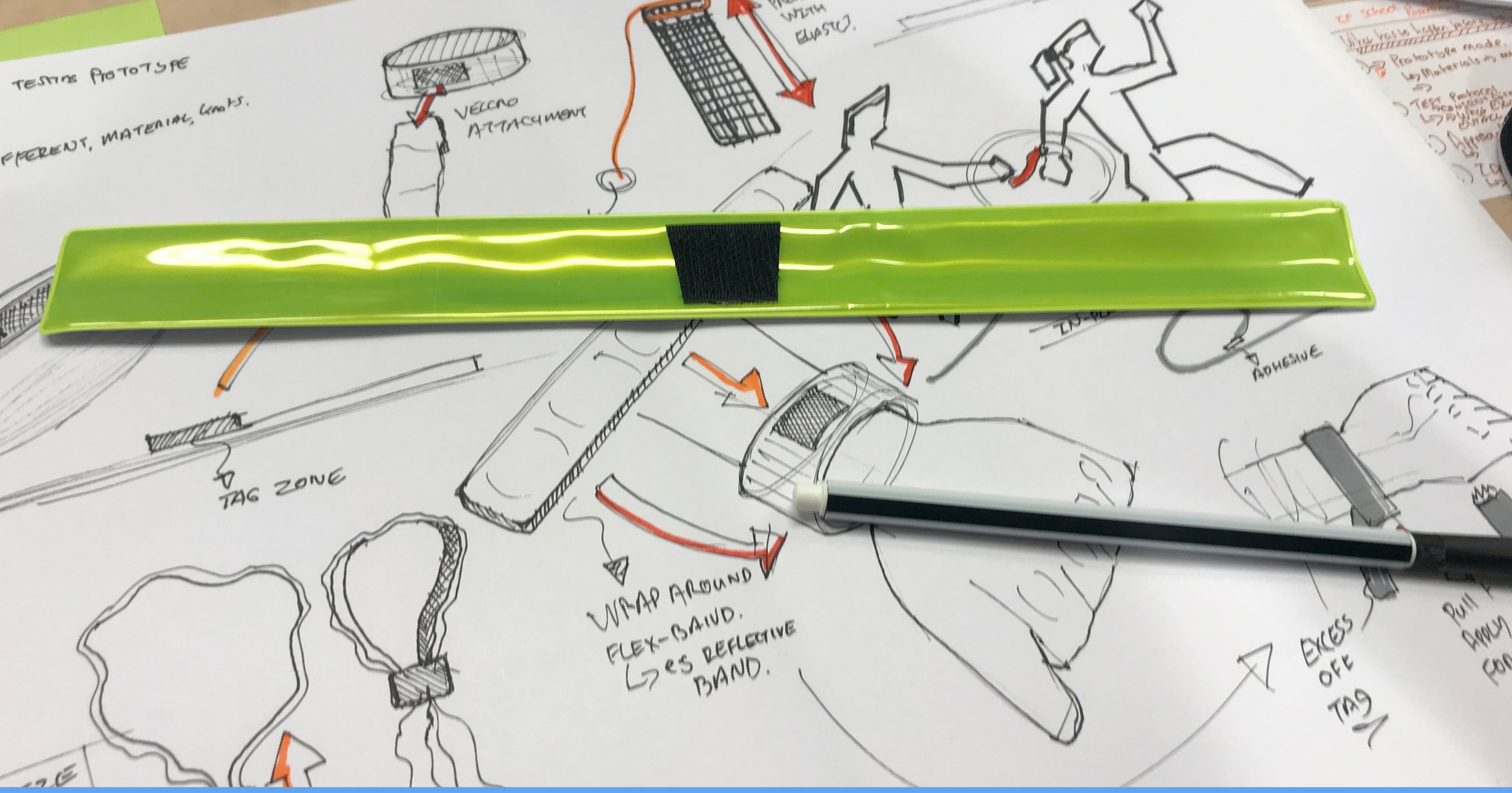


Figure 2.21 : Research gaps established from the “how to’s”.

03

Ideate


TESTING PROTOTYPE
VELCRO ATTACHMENT
WITH ELASTIC.
ADHESIVE
TAG ZONE
WRAP AROUND
FLEX-BAND.
ES REFLECTIVE
BAND.
EXCESS OFF TAG

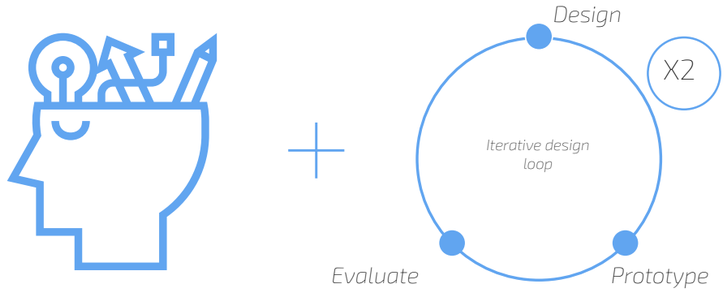


Figure 3.1 : Overview of ideate phase.

3.1 Overview

The second phase of the project was spread over seven weeks. The phase was divided into two blocks:

The first being a 2-week phase of digesting the findings of the previous understand phase and brainstorming for aspects that could be potentially tested.

The second consisting of a five-week block, with two iterative design loops consisting of designing interventions, prototyping and testing the prototypes with children between the ages of 8 to 9 years old at a local school.

3.2 Goals

This phase aimed to uncover information that could not be obtained from traditional research methods such as literature reviews, interviews, etc. In order to do so, ideation revolved around the research gaps established from the previous phase. Some of these gaps were selected to be ideated on and further, developed into test worthy prototypes and be evaluated with the children. The information and insights gathered from these testing sessions and the understand phase were formulated into relevant design criteria (see appendices B) and parameters for the "Make" phase of the project.

3.3 Researh gaps

3.3.1 Defining research gaps

Based on the information and insights obtained from the understand phase, several research gaps became apparent (see figure 2.19). Further clarification was required to determine the gaps that were relevant to investigate for this phase of the project.

Function analysis and flow charts were performed to do so(see figures 3.2 & 3.3). This allowed for a general overview, so focus points based on the Bangerik's functions and sub-functions could be established for further investigation. If there was not sufficient information obtained on an aspect based on insights from the understand phase, it would become a potential focus for the ideation phase.

In conclusion, the areas around stealing lives and eliminating opponents from the game were highlighted as interesting aspects to investigate further during the first iterative design loop. This was decided as these were the primary interaction points between competitors within the game.

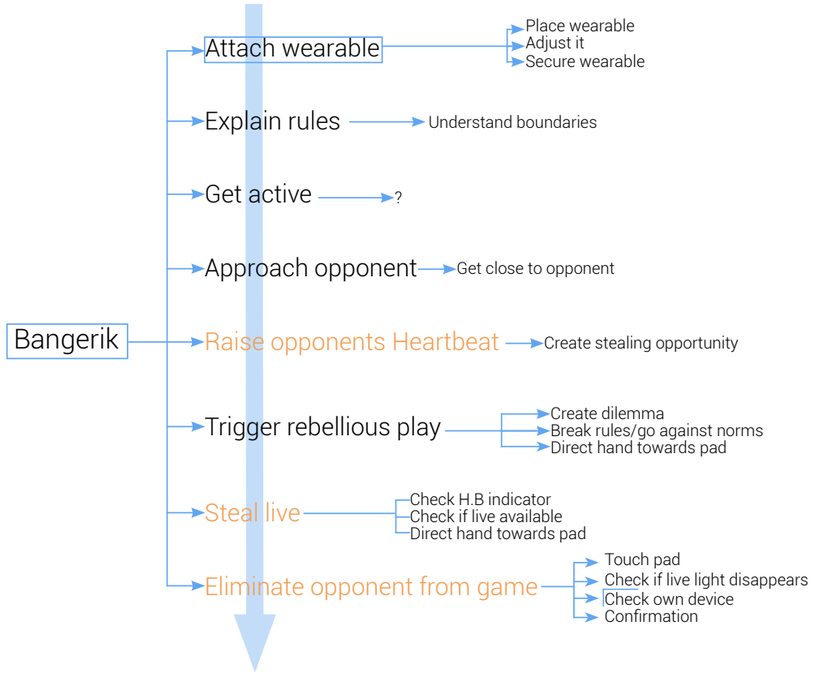


Figure 3.2 : Function analysis of bangerik, potential aspects for further investigation highlighted in orange font.

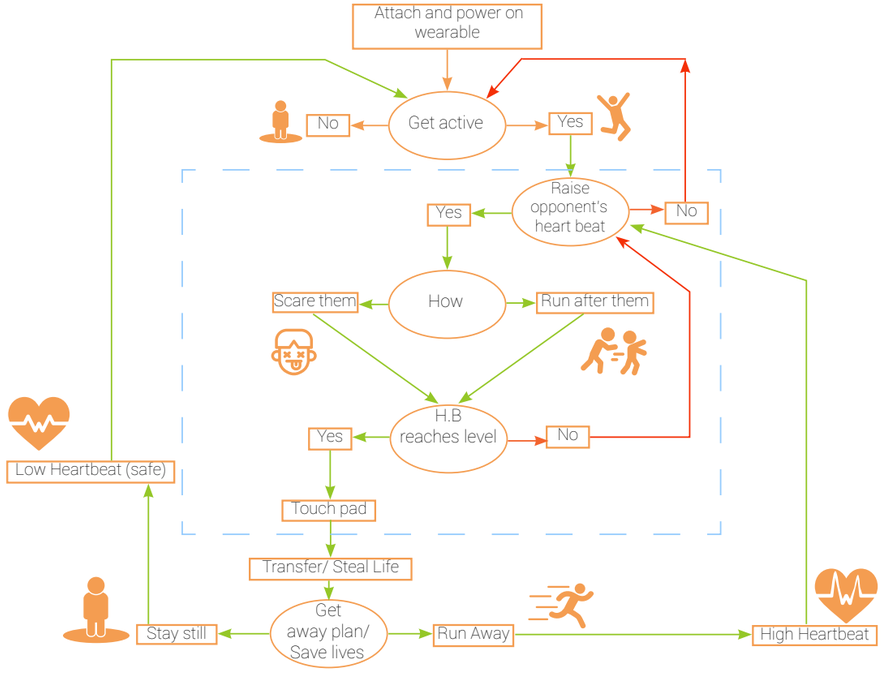


Figure 3.3 : Flowchart of bangerik concept, blue box highlighting the focus for the ideate phase.

3.3.2 The “how to‘s“

Based on the analysis, several research gaps were formulated and translated into “how to” questions as starting points for focus, early in the iterative design loops within the ideate phase (see figure 3.4). The aspects were brainstormed individually and clustered before being combined later in the iterative loop. (See figure 3.5). A more detailed account of the brainstorming outcomes for each aspect can be found in appendices D.

Figure 3.5 : Brainstorming of “How to’s”

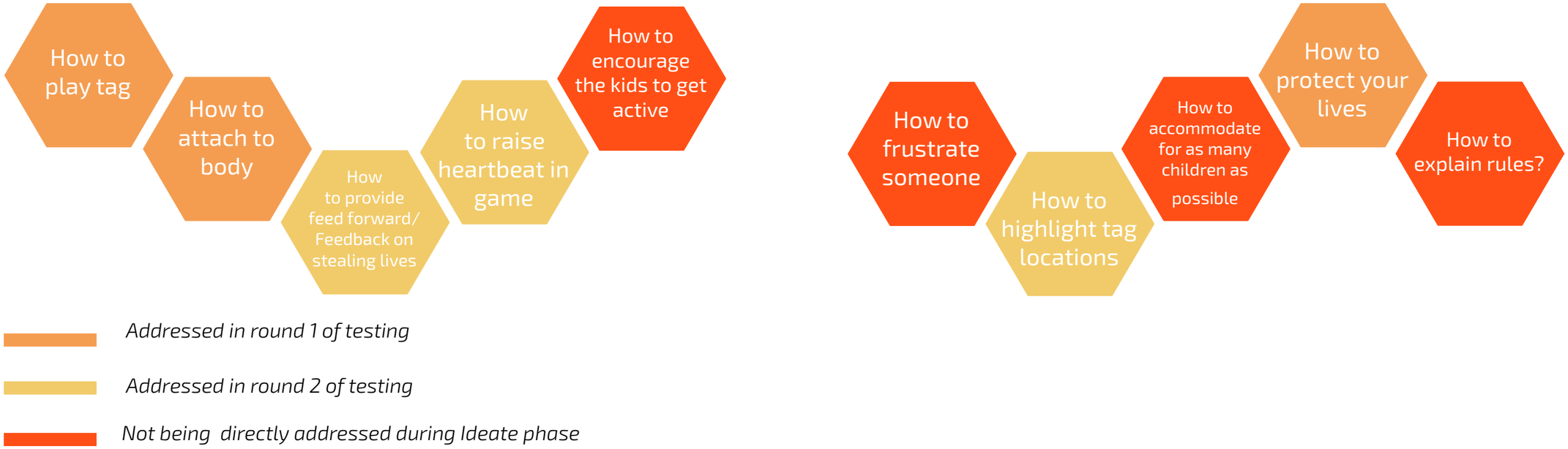


Figure 3.4 : Over view of established “how to’s” and rounds of testing they are addressed in.

3.4 Round 1 goals

Based on the defined research gaps from figure 3.4, three “How to’s” were selected to be investigated due to their interdependence upon each other and the similarities to the original Bangerik. The selected aspects are as follows:

-How to play tag with Bangerik.
-How to attach something to the body
-How to highlight tag/ touch locations.

As the author had no experience of the behaviour of the previous prototype, it was decided for the first prototype to attain similar feature such as the form and size of the original bangerik concept so that similar behaviour might be provoked and hence investigated.

3.5 Round 1 process

3.5.1 Morphilogical chart

With the focus of the first round in mind, the outcomes of the brainstorming were brought forward into a morphological chart (see figure 3.6). A total of 41 combinations were generated systematically and later converged into seven visualised concept directions. The convergence to these concepts was assisted by comparison to initial design criteria established (see appendices C). It was also determined to take an analogue approach in terms of the prototype behaviour for the sake of convenience and efficiency during the first iterative loop.

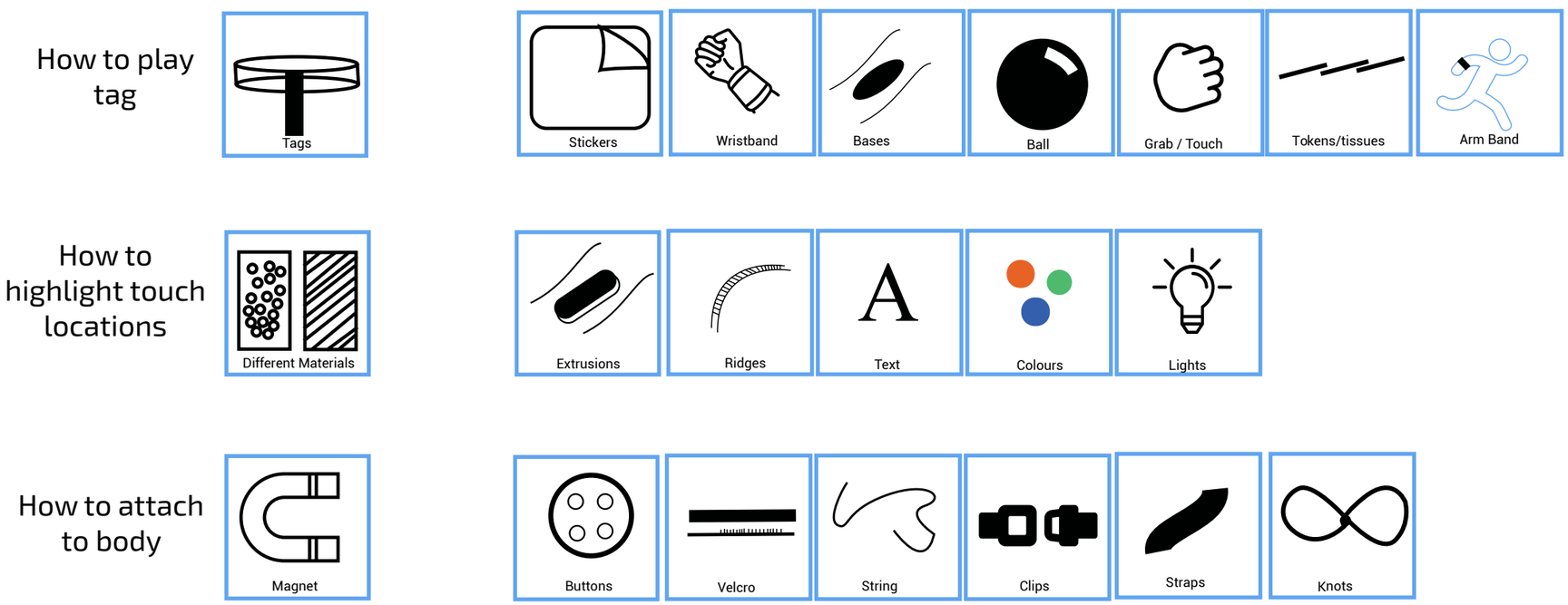


Figure 3.6 : Morphological chart for the first round of ideation.

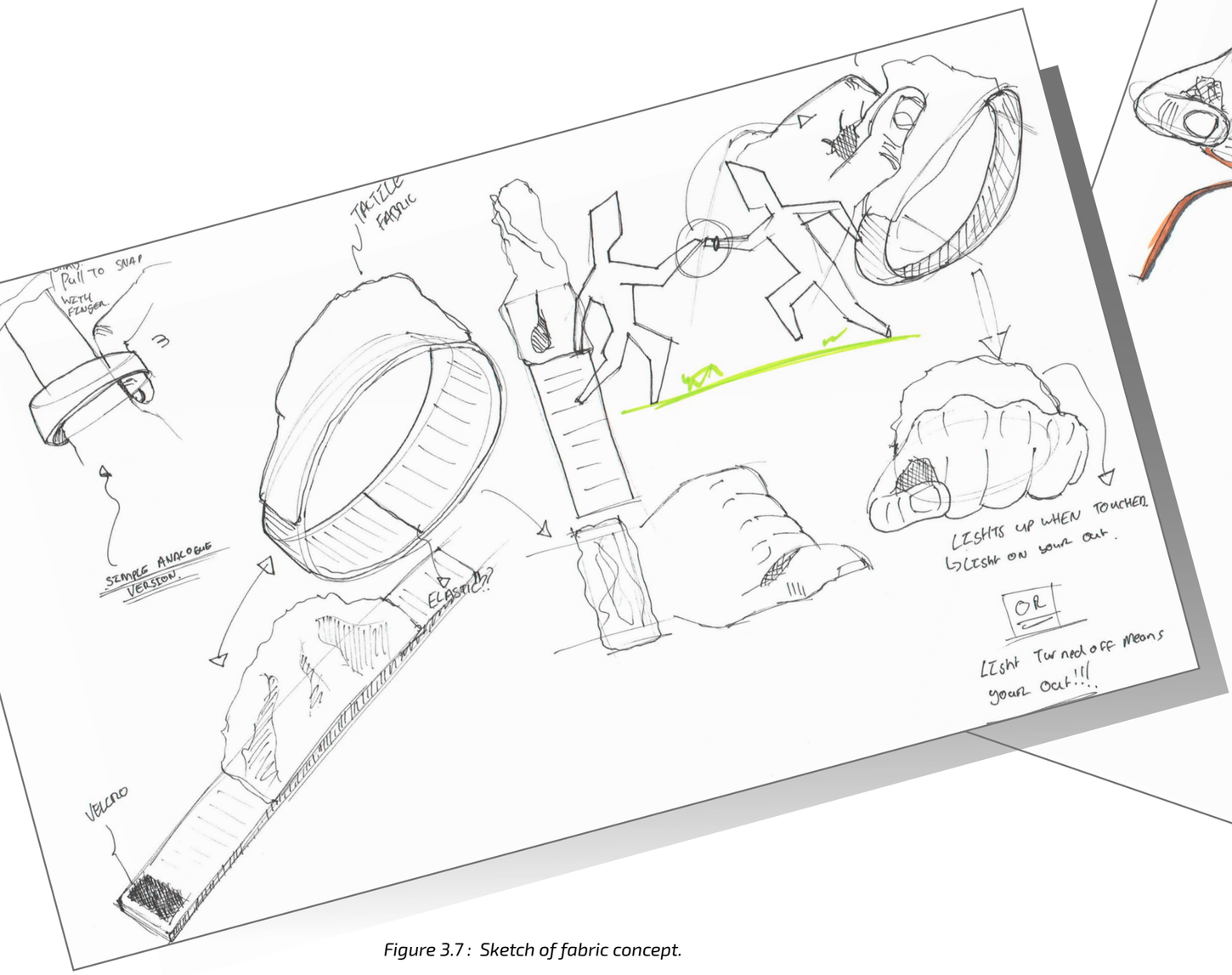


Figure 3.7 : Sketch of fabric concept.

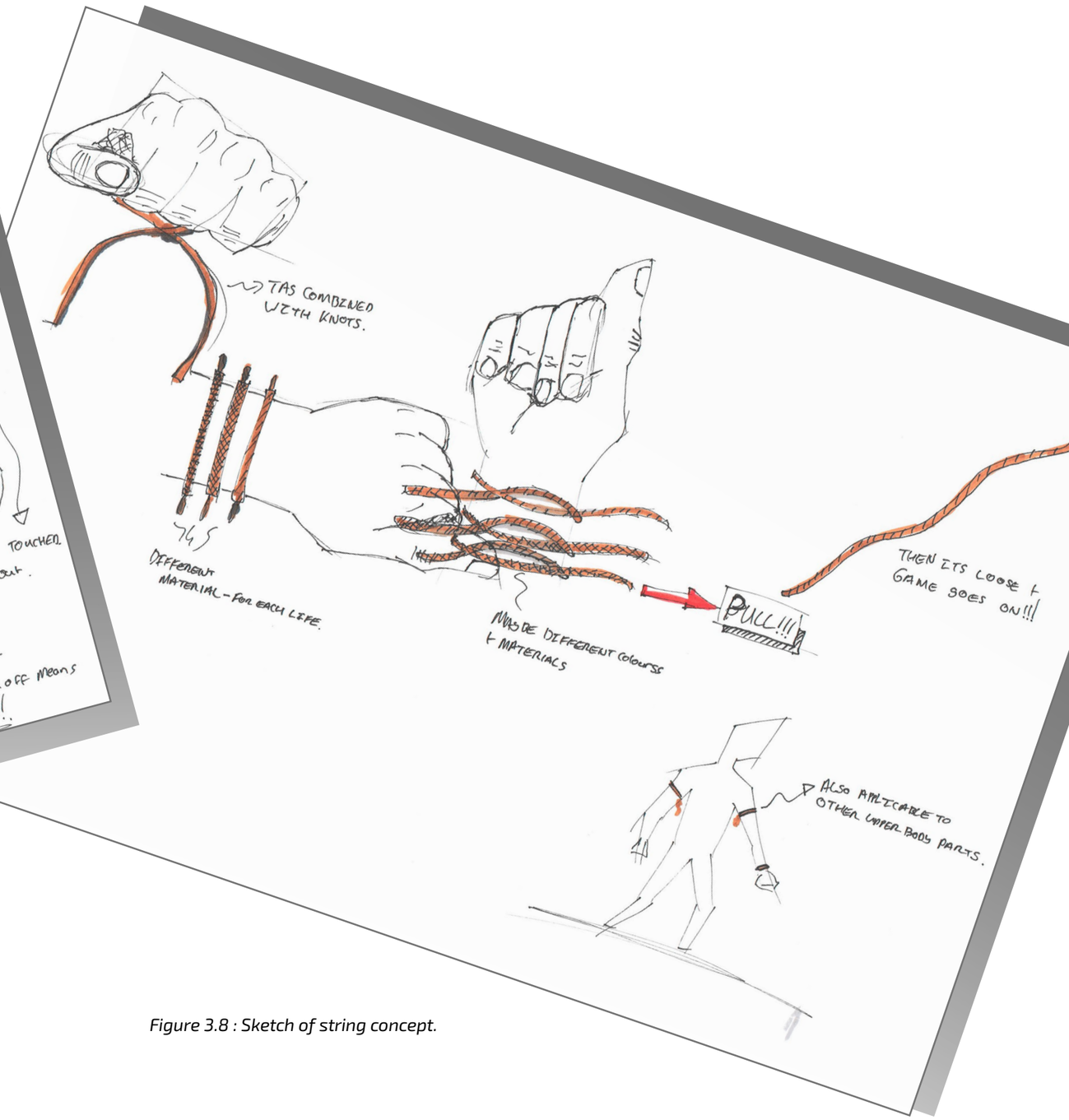


Figure 3.8 : Sketch of string concept.

3.5.2 Ideation outcomes

Fabric concept

From the author's previous experience of playing tag and chase as a child, catching the opponent by their clothing was a favourite tactic on the schoolyard. The question arose whether this could be replicated by having designated areas of the body exposed with pieces of fabric to catch. Two options revolved about the removal of the piece. The material could be attached to the bands using magnets and when removed the wearer is out of the game. Alternatively technology could be integrated within the fabric, in the case that it is touched it activates a LED to flash or a vibration motor to operate to indicate that they have been tagged and are out of the game

String concept

The string concept came upon experimentation with para-cord, wool and threads tied in a semi knot. As soon as the string is pulled, it is effortless to release off the arm. However, questions remain about the safety and material selection of the concept. If the material is thicker in width and more rigid in its behaviour, it holds the risk of constricting the designated tagging areas on the children and potentially hurting them.

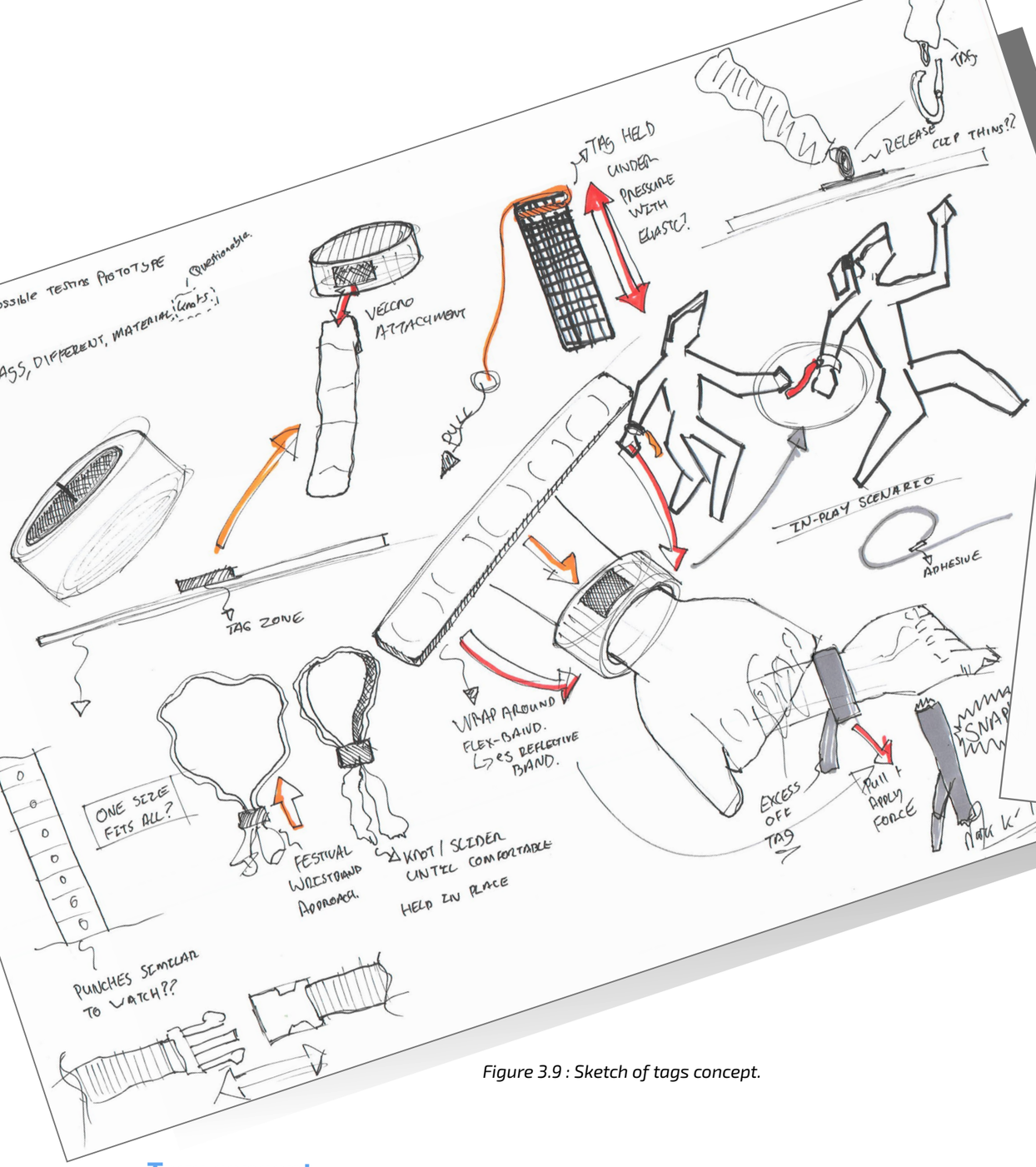


Figure 3.9 : Sketch of tags concept.

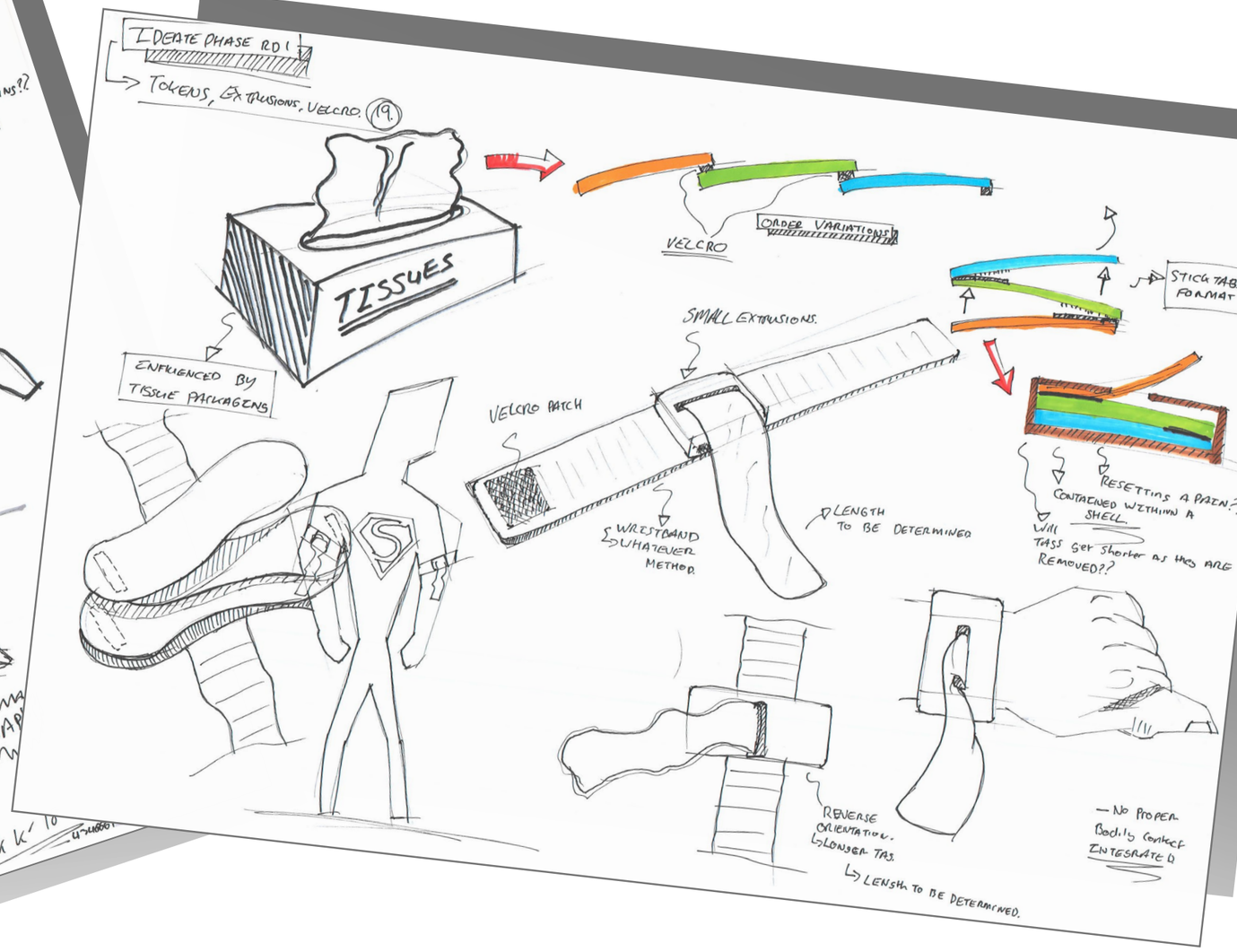


Figure 3.10 : Sketch of tissues concept.

Tags concept

The form of this concept was influenced by the tagging system used in non-contact versions of contact sports such as rugby and American football. They consist of straps with Velcro attachments. Similar to the previous concept, once all the tags are removed off their body they are out of the game.

Alternatively, a similar effect could be achieved through single pieces of material and a small amount of adhesive applied to fit securely around the body part (see bottom right of figure 3.9). A part of the tag is exposed, and when pulled on, it should easily rip off from the children's body part indicating that they are out of the game

Tissues concept

The mechanics of a tissue box and label dispensers influenced this design (see figure 3.10). The idea revolved around letting the children participate in play for a longer duration, hence allowing more insights to be obtained during testing. Each unit contains three tags to represent three lives.
When one tag is removed, another tag is revealed and exposed for tagging. When all three tags are removed, they are out of the game.

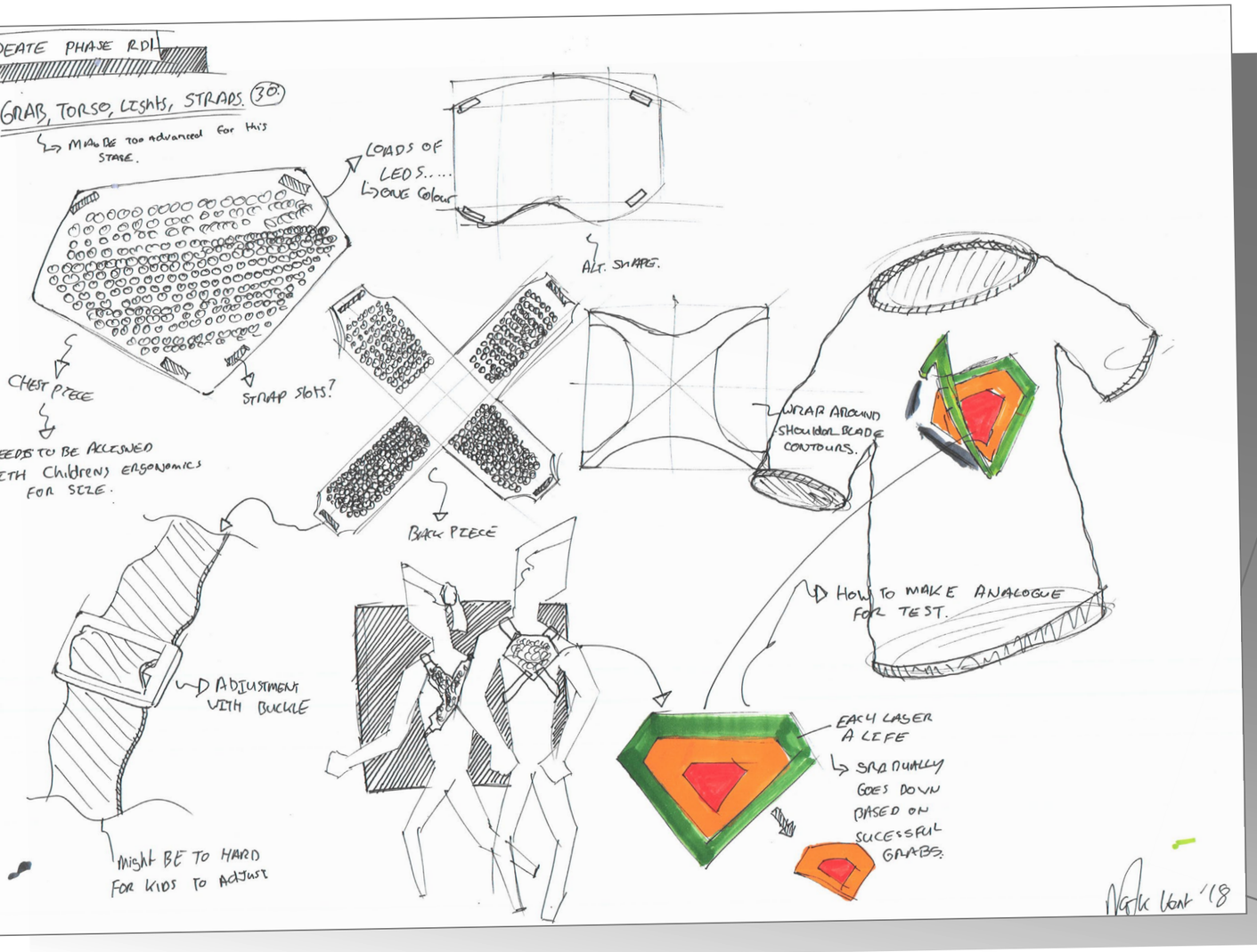


Figure 3.11 : Sketch of peel concept.

Peel concept

The seamless nature of laser tag influenced the idea of a garment covered in LEDs. However, an analogue approach would be preferable for testing as electronics were not considered during this stage of ideation. This brought about the idea of the children wearing a garment with Velcro attachments on the body (see right of figure 3.11). It holds similar principles to the previously outlined tissue concept to try extending the gameplay the children have during testing. It would focus on the children having three lives, and once the attachments are removed, they are out of the game.

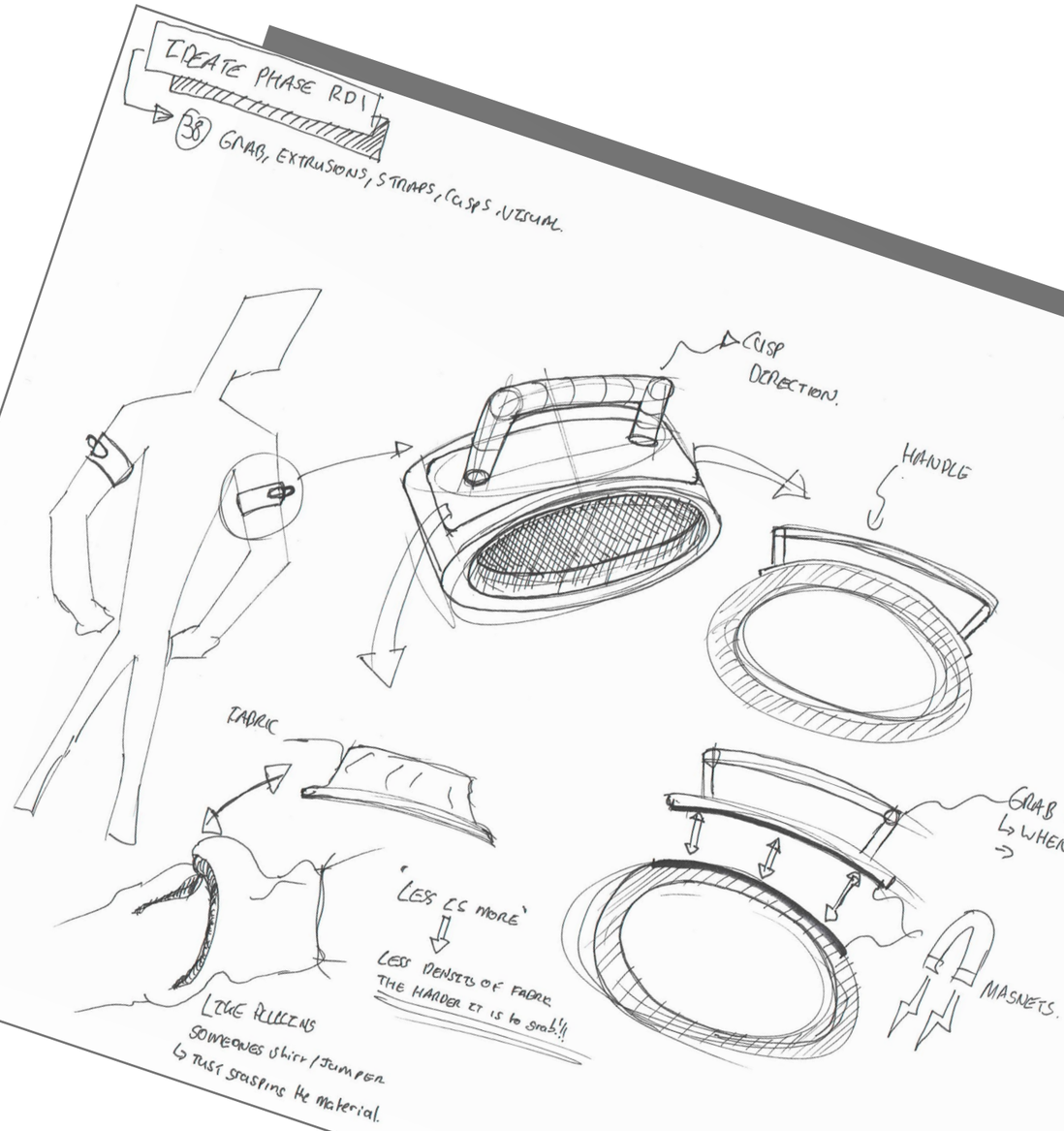


Figure 3.12 : Sketch of handle concept.

Handle concept

The handle concept revolves on the principles of fine motor skills, similar to the fabric concept outlined earlier in this section. These could be attached to the desired body part with straps containing Velcro or magnets. Once all their handles are removed from their upper body, they are out of the game.

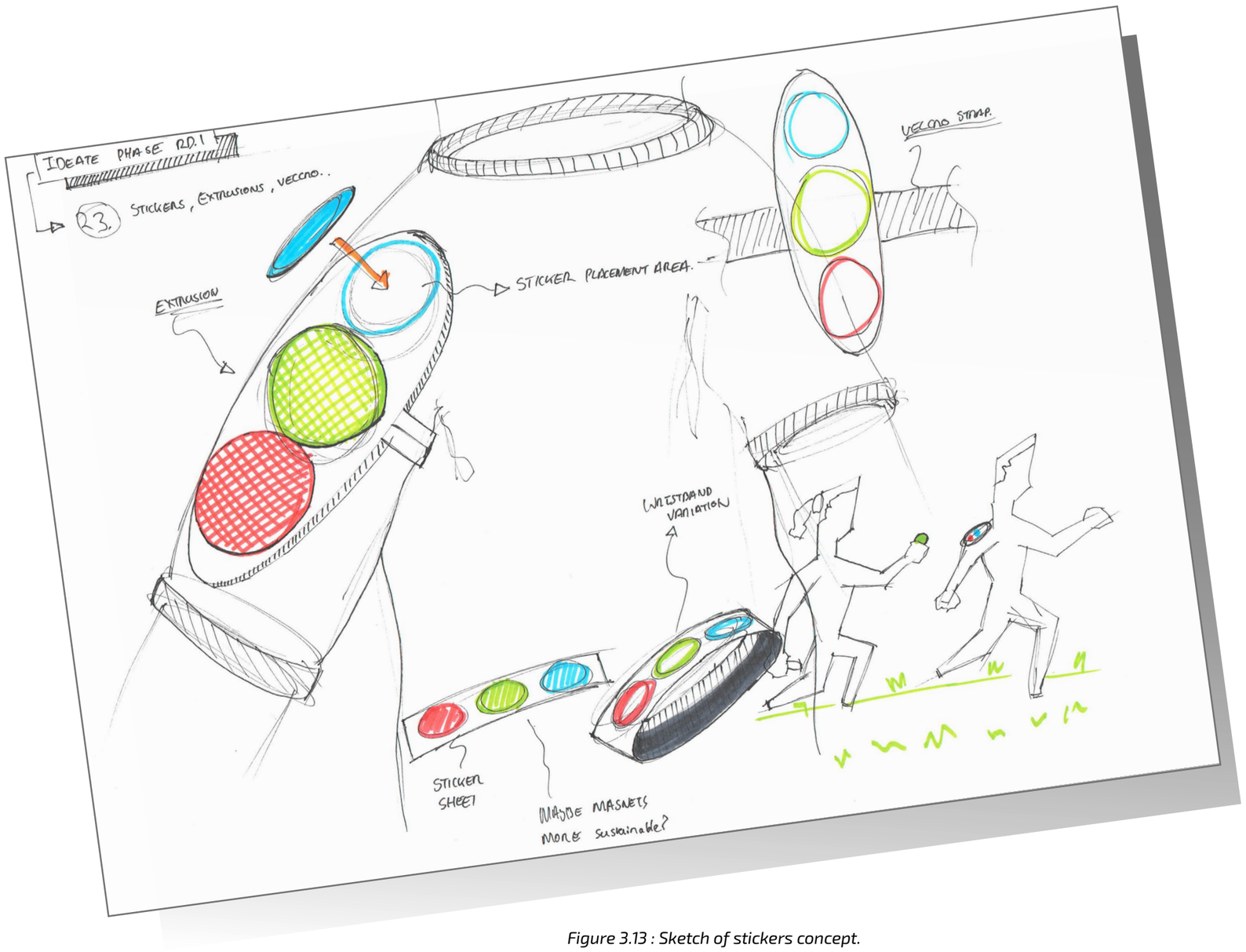


Figure 3.13 : Sketch of stickers concept.

Stickers concept

Similar to the tissues concept, the sticker concept revolved around the same idea of allowing for a longer continuous duration of play during testing. The children would be a given a colour coded set of 3 stickers to represent three live. Their goal then was to attach these stickers to the corresponding spots on the sticker pad attached to the opposing player's body. When the sticker pad is full of the corresponding stickers, they are out of the game.

3.5.3 Final direction

A Harris profile was used to make a decision for a concept to be developed for the first testing round. Design criteria were applied with the most relevant criterion for the testing sessions applied for the Harris profile (see figure 3.14). Furthermore, the criteria are ranked in importance from bottom to top.

The criteria selected are outlined in table 3.1 below describing the motives and meaning for each criterion.

Ultimately the tissue concept was chosen due to its potential to support natural play, it comes across as relevantly safe and accompanied by the envisioned difficulty of actually tagging and protecting lives. The concept also holds a high level of involvement in terms of the number of children that can participate and the duration it enables them to participate in the game due to the „lives“ element of the game.

Criteria	*Meaning and motive for selection*
1. Natural	-Natural is interpreted in the sense that it seems familiar and similar to a game a child may play. -This is important, as it should immediately allow the child to understand how to play the game.
2. Safe	-Safety is essential, as the child must feel safe in order to play. -Safety is mainly interpreted as the risk of physically hurting other players with their interactions during play with the prototypes.
3. Difficulty	-This refers to how difficult it is to tag each other in the game. -If it is too easy the game is over quickly with little insights gained. -While if it's too hard the children may get frustrated and fed up with it.
4. Involvment	-The potential to involve as many children as possible for a sustained period of time. -By having more participants and extending the game duration allows for more insights to be gathered during testing.
5. Set-up	-This refers to how easy it is to set up the prototypes prior to each round within the testing session.
6. Obvious tag	- How clear is it that a child has been tagged in the game with the prototypes. -This is enforced in hope that a "winner" is clarified by the end of the testing round

Table 3.1 : Harris profile criteria meanings and motives

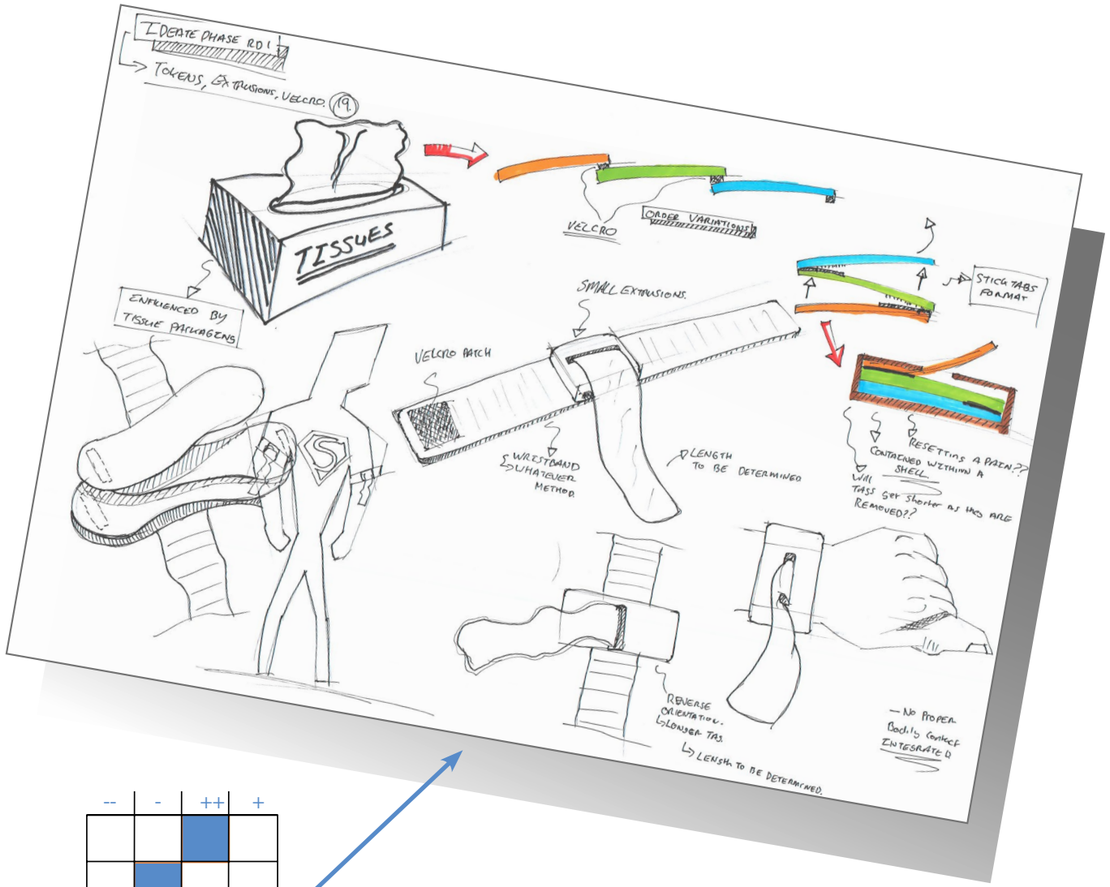


Figure 3.14: Harris profile criteria meanings and motives

3.5.4 Prototype

The developed prototype consisted of pre-cut tags, Velcro, 3D printed shells and elastic straps. Technical details and dimensions of the prototypes can be found in appendices E. Ergonomic principles were applied in the prototype with regards with the lengths of the elastic straps to wrap around their arms and chest, and the length of the shells.

The tags were deliberately kept short to simulate the accuracy and fine motor skills required to tag the touch point in the previous Bangerik concept so that comparisons could be made during testing. The dispensing system was adjusted accordingly with the amount of Velcro applied to each tag and the slot in the shell, to ensure that enough force could be applied to remove the tag and ensure that the next tag would be available for tagging and stealing. Due to the mechanics of the tagging system, the tags needed to be longer. Hence making the shell bigger (see figure 3.15). It is a bit large for a child's arm, however, it did not interfere with the testing.

The construction of the prototype involved placing the three tags within the shell, exposing a single tag through the slot and sealing the unit to the base and strap using masking tape. This approach was decided for the sake of resetting between testing rounds or during testing rounds if running repairs were required. A total of 18 were created with 3 of them tailored to fit around the chest.

Figure 3.15: Prototype attached to the arm of the author.

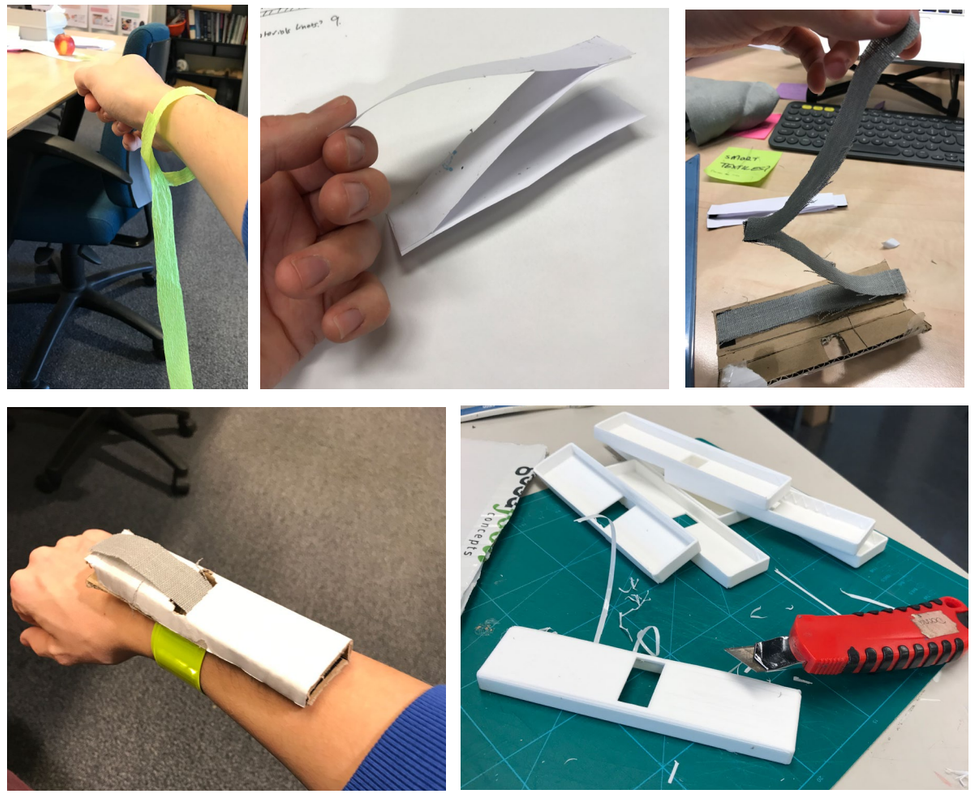


Figure 3.16 : Prototyping process.

3.6 Round 1 Testing

3.6.1 Research goals

Given that the focus of the first iterative design loop of the phase revolves around the dynamics of playing tag, where to place the tags and highlighting the tagging areas, the following research goals were formulated:

(1). Where is the most suitable area to place a wearable on the child's body during play?

(2). Which combinations of placements compliment each other during play.

(3). What are the different strategies per mode worn- Attacking and defending

(4). Which area allows for more instinctive interactions during play?

(5). Is there an equal amount of opportunities to protect lives and to tag others?

Figure 3.17 : Testing with children at school gymnasium.

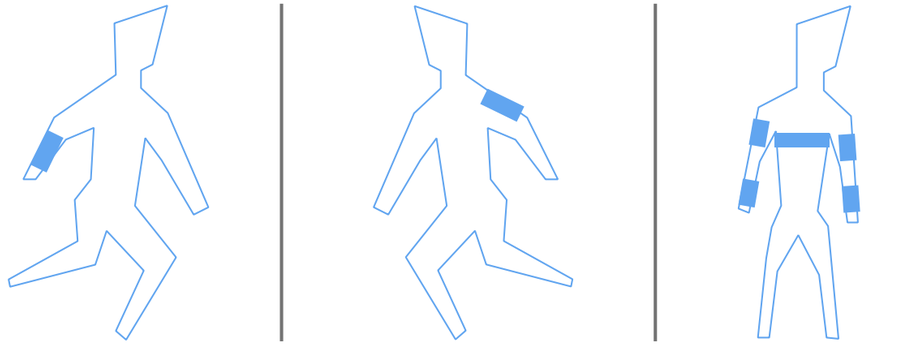


Figure 3.18 : Session outline

3.6.2 Set-up

The testing was conducted with 11 participants (six males & five females) aged between 8 to 9 years at a local school.

The testing session was conducted within the confines of the school gymnasium located within the school building (see figure 3.17). This decision was taken based on the due to the inclement weather conditions outside and for the safety of the participants.

The 11 participants were divided into groups: first group consisting of six (three male and three female) and five (three male and two female) respectively.

The sessions consisted of 3 rounds of play, where the children would wear the prototypes on the various locations on their upper body. (see figure 3.18). The children were free to do what they wanted throughout the testing on the condition that they do not try to physically hurt each other.

Data was gathered from the observation session through video recordings.

Furthermore, the testing session per group was approximately 25 minutes in duration, and followed the sequence of events outlined below:

- Pre-test arrangements- Gathering consent forms and collecting children from the classroom: 3 minutes
- Introduction and outlined instructions: 1 - 2 minutes
- Fitting children with prototypes: 3 minutes
- 7-10 minutes of play and continuous resetting of prototype if required. (per round)
- 2 minutes for children to ask the facilitator questions with regards to the task at hand.
- Reset prototypes and recording equipment and attach prototypes to children for next round of testing. (10 minutes)

A full detailed set-up can be found in appendices F.

3.6.3 Results

(1). Where is the most suitable part to place a wearable on the child's body during play?

Based on initial observations at the field and the analysed footage, the upper arm was the most suitable followed by the chest.

(2). Which combinations of placements compliment each other during play?

Between the combinations tested (wrist/ chest, wrist/upper arm, upper arm/chest) the upper arm and chest appeared to be the best combinations that complimented each other during play. This was primarily due to the opportunities they brought about in terms of the attacking and defending strategies implemented. However, it was noticeable that the tagging was slightly easier than protecting tags.

(3).What are the different strategies per mode worn- Attacking and defending?

The strategies implemented for tagging and protecting were similar across all modes worn throughout the testing session. The attacking and defending strategies for the prototypes while worn on the wrist, upper arms and combination are outlined in table 3.2 below.

Attacking	*Defending*
Wrists	
-Catching opponents off guard. -Getting opponents stationary. - Wrestling -Grappling	-Create distance between other at start of game. - Hide prototype behind back. -Lie on floor, lean against floor, sit on couch, with hand behind back. -Play "dead" weight. -Cover their prototype with their clothing. -Place prototype on inside of arm. -Kicking
Upper arms	
-Catching opponents off guard. -Getting opponents stationary. - Wrestling -Grappling -Isolate wrist from rest of body. *-Remove entire tagging unit from opponent's wrist.*	*-Covering prototype with hand.* *- Hiding under table's blankets and in closets.* *-Pushing* *-Hands off* *- Using foreign objects to defend themselves (e.g. pillows & blankets)*
Upper torso combinations	
-Catching opponents off guard. -Getting opponents stationary. - Wrestling -Grappling -Isolate wrist from rest of body.	*-Covering prototype with hand.* *- Head-butt's* -Grappling from behind and swiping tags - Using foreign objects to defend themselves (e.g. pillows & blankets) *-Rolling shirts over chest prototype*

Table 3.2 Attacking and defending strategies while worn on the wrists, upper arms and upper torso.

(4). Which area allows for more instinctive interactions during play?

The upper arms accommodated the most interactions during play. The upper arms were more instinctive in the sense that they replicated interactions and movements similar to games the author played in his childhood such as tag, cops and robbers and "tip the can". This was closely followed by the wrists and chest.

(5). Is there an equal amount of opportunities to protect lives and to tag others?

The upper arms accommodated the most interactions during play. The upper arms

The balance between tagging and protecting opportunities in the game in its current form is not equal. Tagging appeared as increasingly difficult over time, as opposed to protecting tags throughout all the testing rounds in the session. Only a few participants successfully tagged their opponents throughout the sessions. As more tagging areas were introduced, the opportunities to tag rose. However, it still favoured those who opted to protect their tags as they could still cover their tags in most cases. A summary of the difficulty observations can be found in table 3.3 below.

Mode	*Difficulty observations*
Wrists	-Appeared to be the most difficult area to tag as the children's wrists were constantly swinging motor co-ordination while in motion. -Tagging opportunities also remained limited as they could be easily covered with their clothing or their hand to protect them.
Upper arms	-The upper arm offered more tagging opportunities and made protecting tags more challenging due to the restricted biomechanics of the area.
Upper torso combinations	-As there were multiple body parts utilized, a dilemma was created where there was usually area exposed at all times. -The participants usually had the option to protect one area and leave the other area vulnerable to tagging. -Tagging did increase, but the children got creative in protecting their tags as previously,mentioned in tables 1,2,3.

Table 3.3 Summary of difficulty while attacking and defending strategies per mode.

Figure 3.19 Children testing the upper torso combinations .

3.6.4 Limitations of study

Several limitations arose during this first testing session of this phase.

The test was initially scheduled to take place in the school playground. Due to cold and inclement weather conditions, the teaching staff requested that the test be conducted in the confines of the school gymnasium. This was also decided for the convenience of supervision. Gymnasiums are often associated with provoking more hyperactive, brash behaviour and may not resonate with their behaviour in their daily contexts.

The school and its staff were also experiencing a busy transition period as they prepared to move to new premises nearby. The school had a relaxed and less rigid structured approach to teaching activities on their schedule. This possibly allowed the children to behave in a more excited chaotic manner. This behaviour could also have been possibly heightened with the approach of the Christmas vacation.

The tests were conducted with a small number of participants over a short duration of time. Hence the effects of playing this game throughout the duration of a day are unknown with regards to the strategies undertaken and the behaviours provoked.

The testing at one point was improvised due to the perish-ability and robustness of the prototypes used in the sessions. This mainly affected the method of attaching the prototypes around the designated body parts shown in figure 3.18.

3.6.5 Conclusions

From the testing session, several answers could be clarified with regards to the research goals of this study.

Even though all the parts offered a degree of difficulty to tag, the upper arm seemed to offer the most opportunities in terms of tagging, followed by their chest. This was especially the case when the children are running and using their arms to balance themselves in motor coordination, leaving this area exposed. A chest and upper arm combination is preferable.

None of the areas was entirely suited as an separately for tagging as the opportunities were limited. Adding more tagging areas opened the game up a lot more and created similarities to a typical game of tag, involving more chasing.

Having a combination of tagging areas required them to approach things differently on both attacking and defensive fronts. With this in mind, the difficulty should be further investigated and optimised to ensure that tagging and protecting opportunities are on par.

The interactions with the prototypes were more focussed on the participant's fine motor skills to remove tags, rather than just swiping at them. The difficulty in tagging could have been due to the short length of the tags and also the force required to remove them. This may have influenced the intermittent nature of the play observed.

3.7 Round 2 process

3.7.1 Research goals

Upon the outcomes and conclusions of the first iterative design loop the 2nd round of testing focussed on the following themes:

(1.) Raising and lowering Heartbeat
(2.) The whole upper body as a tagging location

As previously mentioned back in section 2.6.1 of this report, the heartbeat element was highlighted as having a central role in the original Bangerik concept, where the goal was to raise your opponent's heartbeat by means of scaring and chasing each other to unlock an opportunity to steal their lives. This was crucial to the whole mechanics and operation of the game as it provided the children with a dilemma of putting their lives at risk by being active (raising their heartbeat) or remain safe by keeping their activity to a minimum (lowering heartbeat).

Yet there was very little information provided or documented the effects of this element in the previous development of the concept. Therefore it is important to validate this assumption before progressing to the next round of the prototyping, to determine whether it should or should not be still incorporated within the design of the final prototype.

Investigating suitable locations for a wearable on the body in the previous testing round, proved to be extremely fruitful. However, it did raise more questions around the form of the prototype and alternative ways to attach it to the body. A combination of body parts (upper arm and chest) brought about a more challenging and interesting scenario for the children during gameplay with regards to strategies they undertook for tagging and protecting their lives respectively. It brought about a more stagnated, intermittent pattern during play. Upon reflection of the outcomes of the previous test session, the suggestion of the use of textiles or garments arose as a potential design direction for the final prototype towards the pilot study. Furthermore, it does hold the properties to highlight and accommodate for the upper torso in a seamless fashion as opposed to the prototypes utilised in the previous test. This should be investigated further, as it could determine the form the game takes in the final prototype.

3.7.2 Morphilogical charts.

Similar to the first iterative design loop, brainstorming outcomes were translated into respective morphological charts (See figure 3.20 & 3.21) for both themes previously described in 3.7.1.

With regards to the heartbeat element of the testing, a total of 3 concepts were generated from figure 3.20 with regards to the heartbeat element of the testing. The concepts were driven by the four factors that follow:

- Where to place the pulse sensor on the body?
- Feedback options
- How to attach the prototype to the body
- And what form the prototype should take based on the material readily available.

Likewise, a number of combinations were generated from figure 3.21, addressing the upper body as a tagging location. The best 3 were selected for further investigation. The combinations were driven by the following factors:

- The body parts it shall accommodate.
- How it will be attached to the body.
- Feedback options.
- How to highlight the tagging locations.

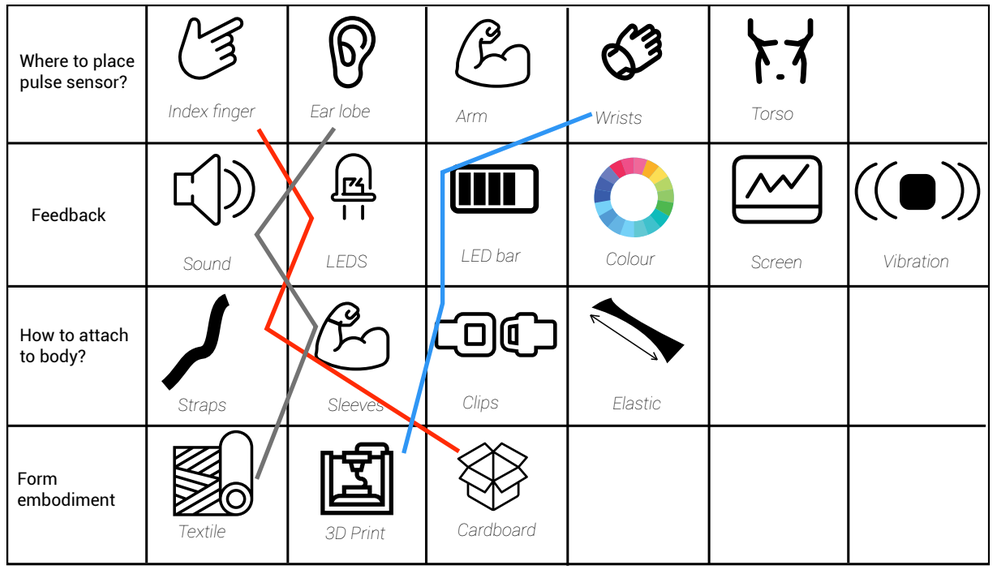


Figure 3.20 : Morphological chart heart rate

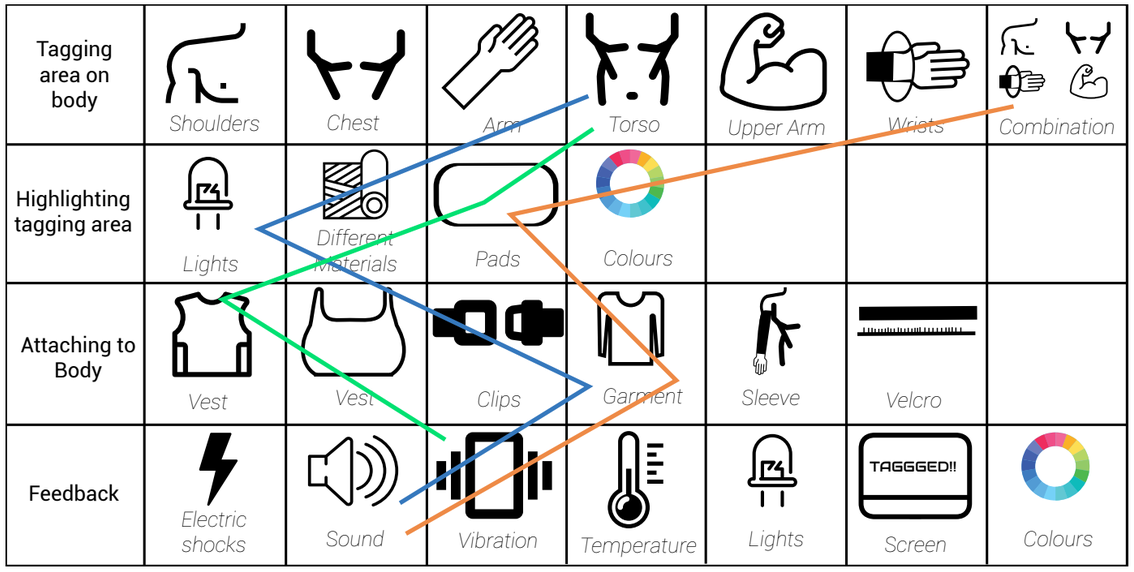


Figure 3.21 : Morphological chart garment

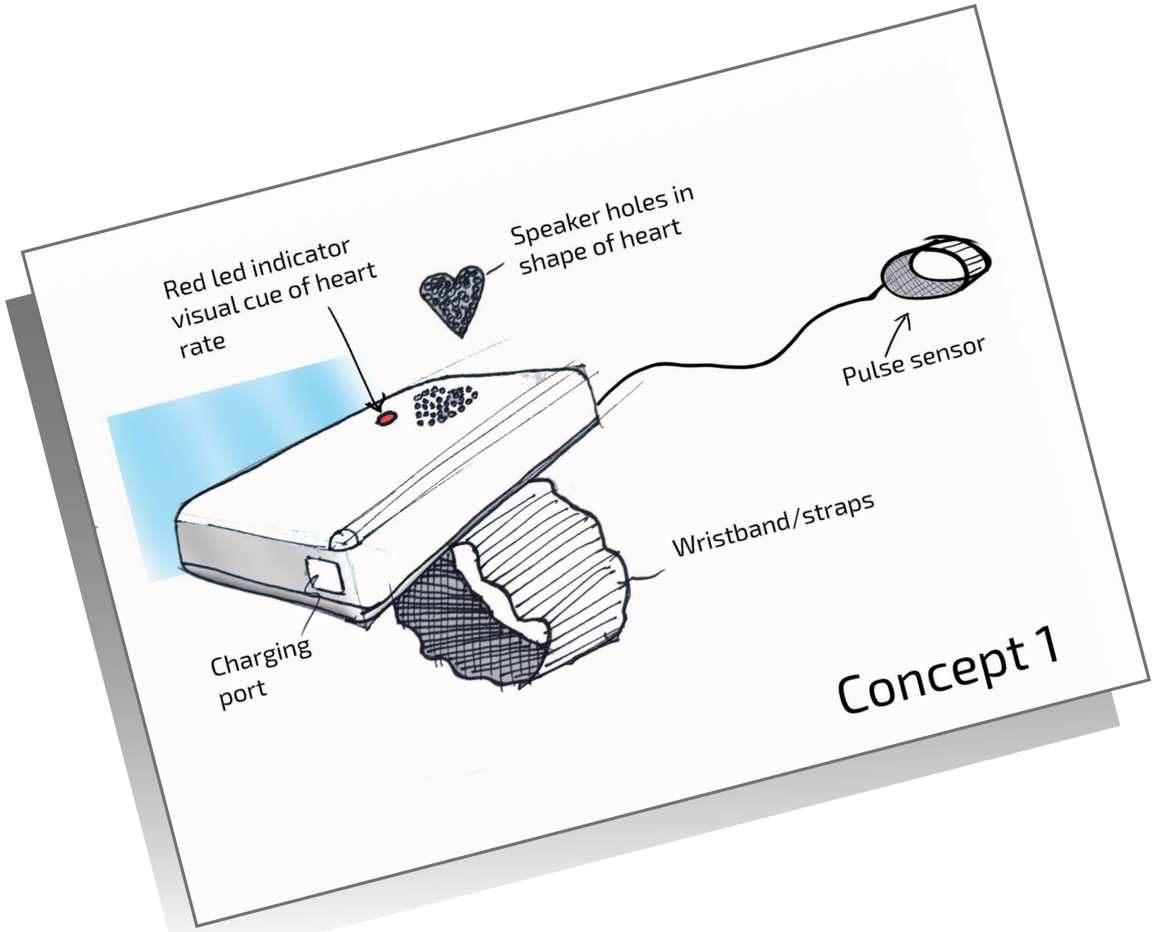
3.7.3 Ideation outcomes- heart rate

3 concepts were generated based on the morphological chart generated in figure 3.20 in section 3.7.2.

Concept 1 consists of a cardboard unit containing electronic components attached to the wrists, with the pulse sensor being placed on the index finger of the participants. The LED will flash in correspondence of the participants heart rate and will sound a buzzer when the threshold is reached.

Concept 2 consists of a LED bar attached to the wrist, with the pulse sensor placed on the inside of the wrist. A traffic light system is implemented to provide the participant information on their heart rate. (Green meaning heart rate is low and red meaning heart rate is high. When the bar is full the threshold is reached.)

Finally, concept 3 consists of the pulse sensor being attached to the participants earlobe. The components are contained within a pocket on the elastic arm band. A buzzer will activate to indicate that the threshold has been reached.



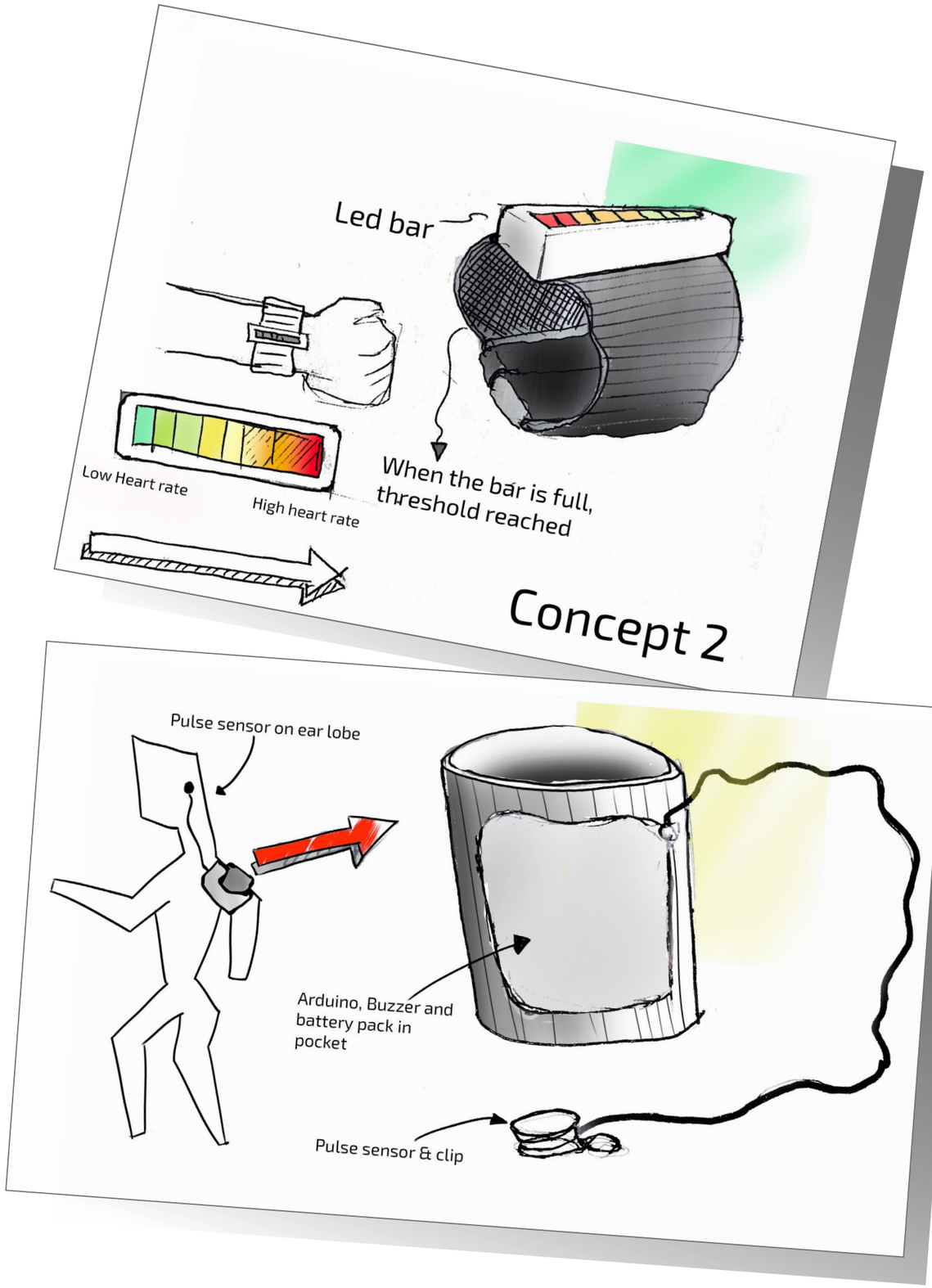


Figure 3.22 : Concepts generated for heart rate prototype

3.7.4 Ideation outcomes- Garment

3 concepts were developed based on the combinations that emerged from the morphological chart generated in figure 3.21 in section 3.7.2.

Concept 1 consists of a vest capturing the upper torso, covered on small illuminated touch points . When these touch point are activated, the vest will vibrate to indicate to the wearer that they have been tagged.

Concept 2 is embodied through a pair of sleeves to accommodate the upper arms. The sleeves are touch sensitive, and when activate will cause the sleeves to illuminate and flash to indicate that the wearer has been tagged. Vibration is used as a means of indicating which arm was tagged to the wearer.

Concept 3 consists of a T-shirt capturing tagging locations on the entire upper body. Similar to concept 2, LEDs are activated when someone is tagged and followed by short intense bursts of sound from a buzzer integrated in the shirt.

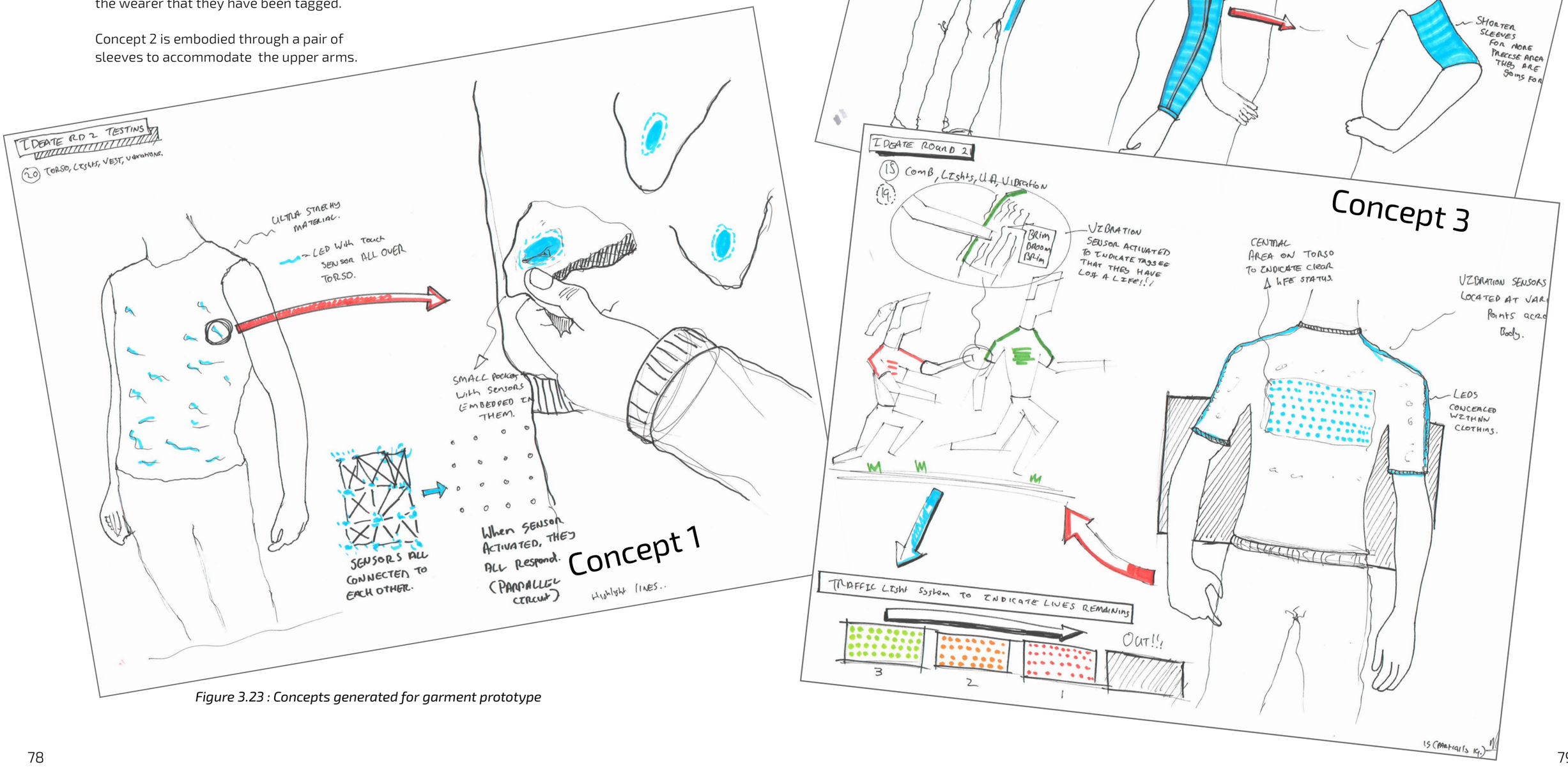
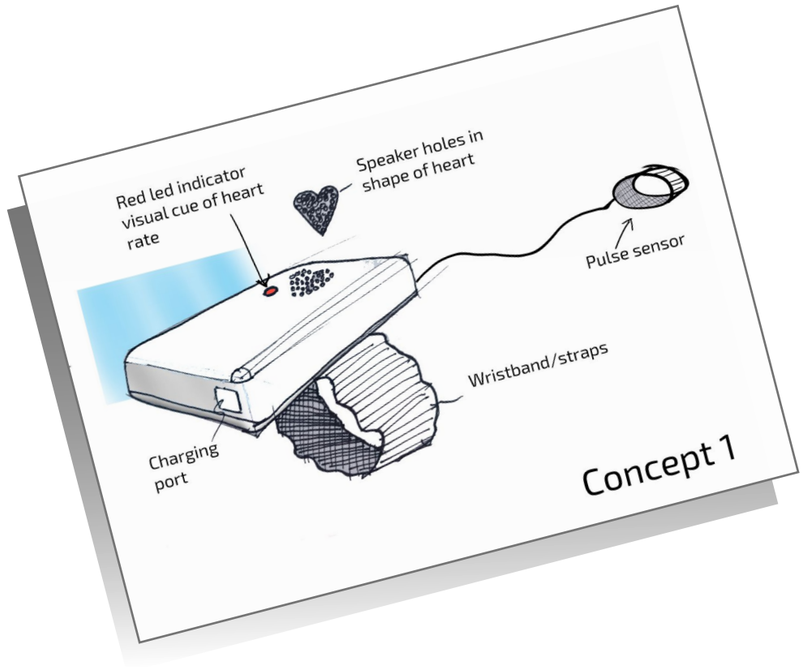


Figure 3.23 : Concepts generated for garment prototype



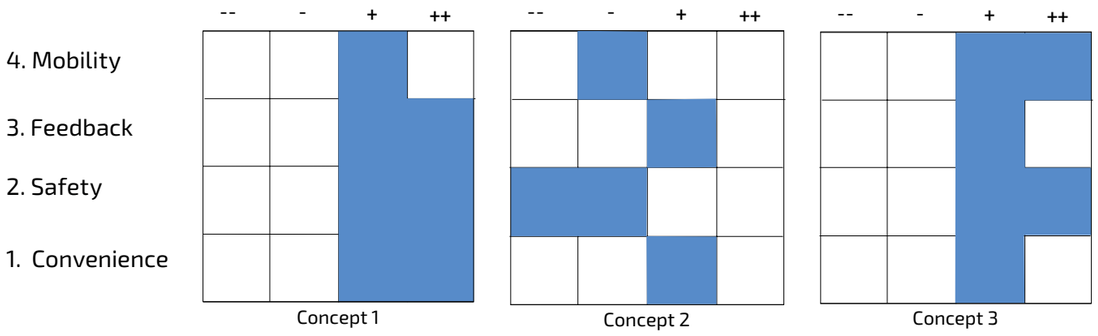


Figure 3.24: Harris profiles outcomes of heart rate prototype.

3.7.5 Final selections

Several limitations arose during this first testing session of this phase.

In order to make an informed decision, a Harris profile was once again utilised with regards to the Heart rate prototype. The concepts were ranked and rated based on the following drivers:

1.Convenience- In terms of prototyping, set up and conducting testing.

2.Safety- Should be able to hold components of the prototype in a secure manner. (Ensuring that the prototype stays attached to the body during testing and minimizing the risk of a child getting hurt.)

3.Feedback- Should clearly indicating that heartbeat has reached the threshold.

4.Mobility- Should not hinder the children's ability to move naturally.

Concept 1 was chosen based on its high rankings with the drivers that were previously outlined.

With regards to the upper body as a tagging location, the combinations previously generated were narrowed down to 3 combinations, with comparison to the previously generated design criteria. (Please see appendices C). The remaining combinations underwent a C-Box analysis. (see figure 3.2.5)The method was adapted to suit the scope of this testing, with the ideas being mapped against X axis' based on the difficulty of prototyping, and the Y axis based on the desired play dynamics.

Upon further review of the analysis above it was decided concept three would be taken to the next phase of the iterative design loop to be created into a prototype. This was primarily due to the ability to accommodate the whole upper body as a tagging location.

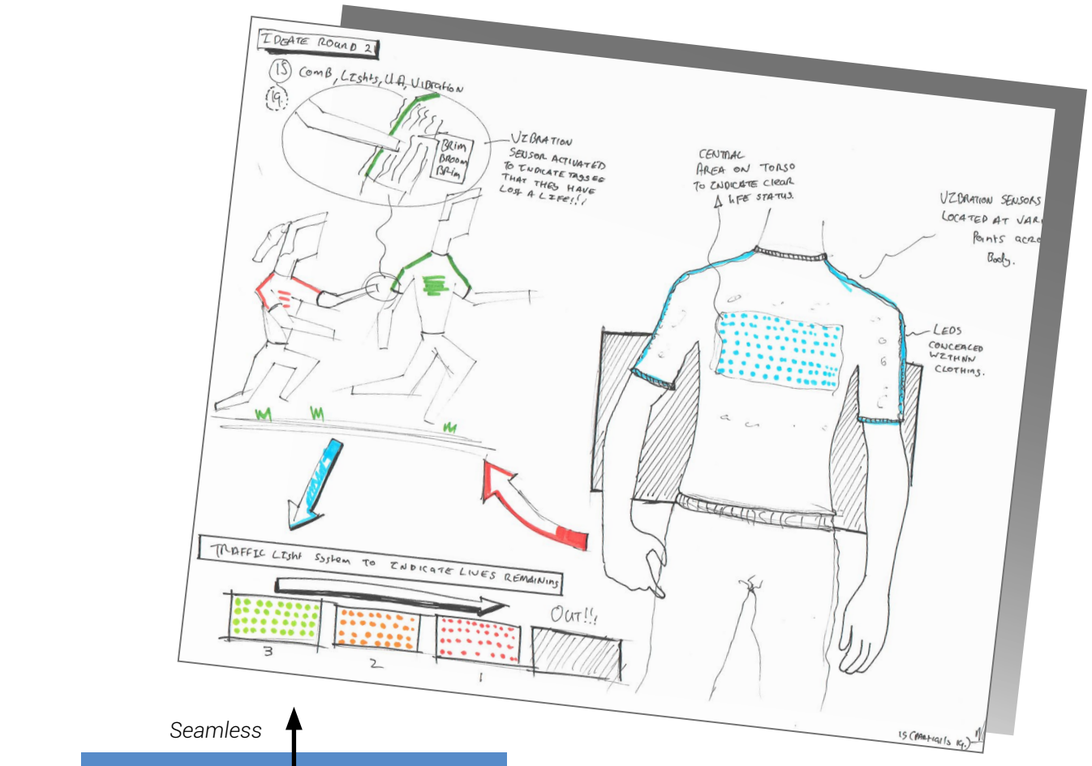


Figure 3.25: C-Box analysis for garment prototype.

3.7.6 Prototypes

It was decided that both testing themes (raising/ lowering heartbeat & upper body as a tagging location) would be tested separately in 2 different prototypes tailored towards each one (see figures 3.26 & 3.27). This was done for the sake of prototyping convenience and clarity during the post analysis of the gathered data from the testing session. Combining both themes into a single prototype would have made it difficult determining which strategies were tailored towards the heartbeat or tagging elements of the game.

The heart prototype consists of an Arduino Uno, a grove shield, a red LED, a Piezo buzzer, a pulse sensor, an Arduino cable and a small 5V power bank encased in a cardboard shell with elastic straps attached. Technical drawings for the cardboard shell can be found in appendices H.

The behaviour of the prototype is simple. The prototype would be attached to the participant, with the pulse sensor placed and secured on their index finger. When the child gets active, the red LED will blink in correspondence with their pulse. When their pulse reaches the high heartbeat threshold (115 bpm) a buzzer will sound to indicate their pulse is high. The code for the prototype can be found in appendices I.

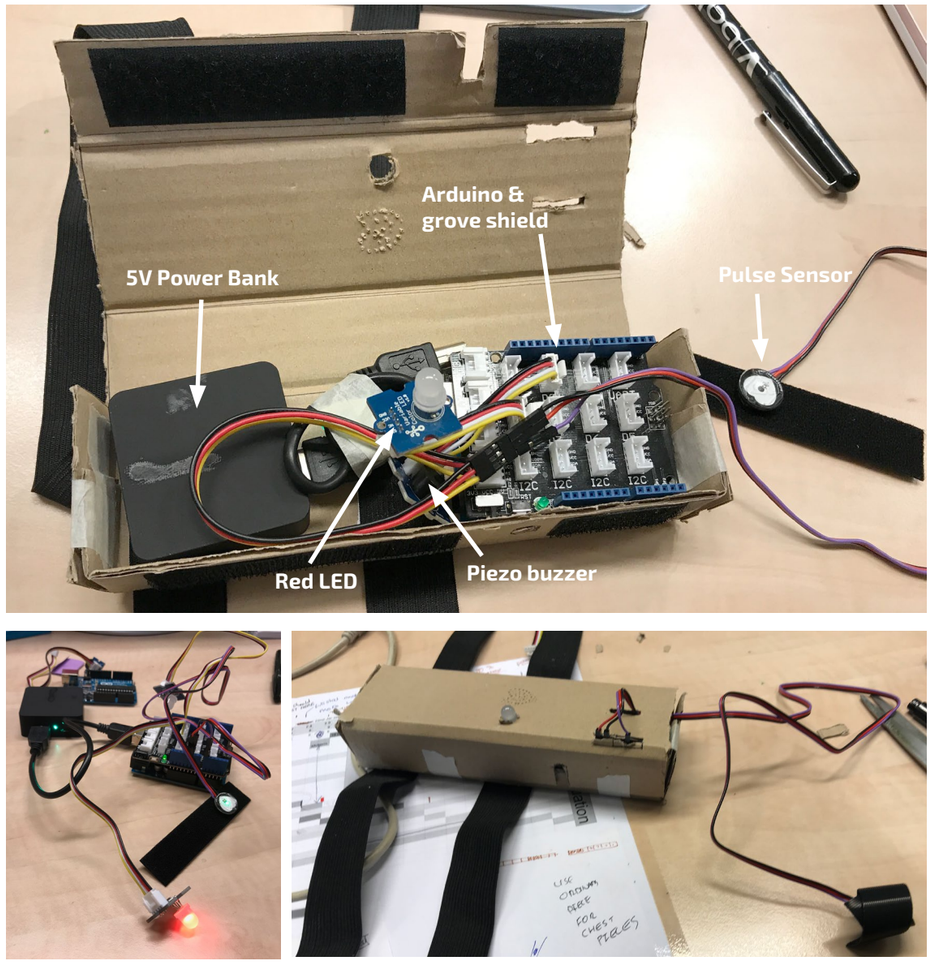


Figure 3.26: Heart rate Prototype: (top) Components integrated in cardboard form, (bottom left) loose components (bottom right) Completed prototype.

Figure 327: Garment Prototype: (top left) Components in box ,(top right) Stitching pattern, (bottom left) completed garment prototype, (bottom right) Garment on child.

The garment prototype consisted of a pre-made children's athletic shirt, two ply conductive thread, an Arduino, LEDs, a Piezo buzzer, a grove shield an I2C grove hub and a Q-touch sensor. The components were stored in a modified lunch box and rested in the front pocket of the shirt (normally used to accommodate a race number).

The thread was applied efficiently to cover as much of the garment as possible. The thread was sewn in a cross-stick pattern to ensure enough thread was exposed on the garment for tagging to activate the behaviour, which is described below. The thread is conductive and when attached to the Arduino board, it transforms the whole length of the thread into a touch sensor.

Similar to the heart rate prototype, the behaviour behind the prototype was straightforward. When the garment was touched it would activate the buzzer to sound and the LEDs to flash, to indicate that the child has been successfully tagged. The code for this behaviour can be found in appendices J.

3.8 Round 2 Testing

3.8.1 Research goals

With the second round of the iterative design loop revolved around the implications of heartbeat element in a game and the suitability of the whole upper body as a tagging location, the following research goals were established for each particular theme:

Raising and lowering Heartbeat:

(1.)Do the children understand how to raise their heartbeat?

(2.)In a game-like situation what strategies do the children have in order to raise an opponent's heartbeat?

(3.)What strategies do the children take to try and lower their own heartbeat?

The whole upper body as a tagging location:

(1.)What strategies do the children use to defend themselves and how do they differ from the 1st testing round of the ideate phase?

(2.)What strategies do the children use to tag their opponents?

(3.)Does having the upper body as tagging location bring about more fluid and natural play?

(4.)Does the upper body work as tagging area/location?

(5.)Is the difficulty between tagging and protecting lives equal, in the game?

(6.)Is it clear that the children have successfully tagged an opponent or have been a victim of tagging?

Figure 3.28 : Testing with children at school gymnasium.

3.8.2 Set-up

The testing was conducted with the same participants that participated from the 1st round of testing. The context for this test was an empty classroom in the newly renovated 2nd floor of the school.

The testing took a similar format to that outlined in 3.6.1, with the session divided into session two parts; with participants first testing the heart rate prototype and then testing the garment prototype.

The notable difference for this test compared to the 1st Ideate testing session is the division of participants into pairs for each test. The children were brought to the test location in two groups and then asked to pair off with one of the classmates. This was decided due to the number of prototypes available , facilitation and for the convenience of analysing the data.

Furthemore, the data was analysed differently The footage was viewed several times, with each viewing addressing and focussed on a single research question. The insights were written down in a notebook accompanied by a timestamp of when it occurred in the footage.

A full detailed set-up for this testing round can be found in appendices J.

3.8.3 Results

Heart rate prototype results

(1). Do the children understand how to raise their own heartbeat?

All the children had sufficient knowledge of the implications and understanding of raising their heartbeat. They knew methods of how they could each individually achieve raising their heartbeat, with some of the children stating and even demonstrating how to do so. The strategies varied on a range of physical activities including, running, jumping and jumping jacks to mention a few.

(2).In a game-like situation what strategies do the children have in order to raise an opponent's heartbeat?

The strategies varied greatly per group, with the first group of participants proving to be the most creative in their unorthodox approach. Quite often opponents would stay still and motionless positions lying on the floor or leaning against a wall. This invited the chaser to provoke some form of a reaction in the hope of physically stimulating their opponent. This triggered strategies such as dragging them across the floor, spinning them on the floor, tickling, grappling and wrestling. The wrestling and grappling occurred when both participants were on the floor or leaning against a wall, with the opponent in a lock position (grappling manoeuvre) and provoking them to try and break free from that position..

The most ironic strategy displayed was removing the opponent's shoes and socks and throwing them to the far side of the room, expecting them to rise up and immediately to retrieve them.

The second group were more traditional with their approach, and they predominantly relied on more traditional strategies such as chasing. The boys were brasher as chasing evolved into sliding on the floor to save energy and try to catch their opponent to grapple and pushing each other. The girls tended to run around in a circle with the chaser taken a central role in the room and along the periphery of the room, ensuring that they had to run a longer distance. Quite often playful teasing was used to provoke a reaction in the hope of creating some sort of physical activity and open up the opportunity to chase each other again.

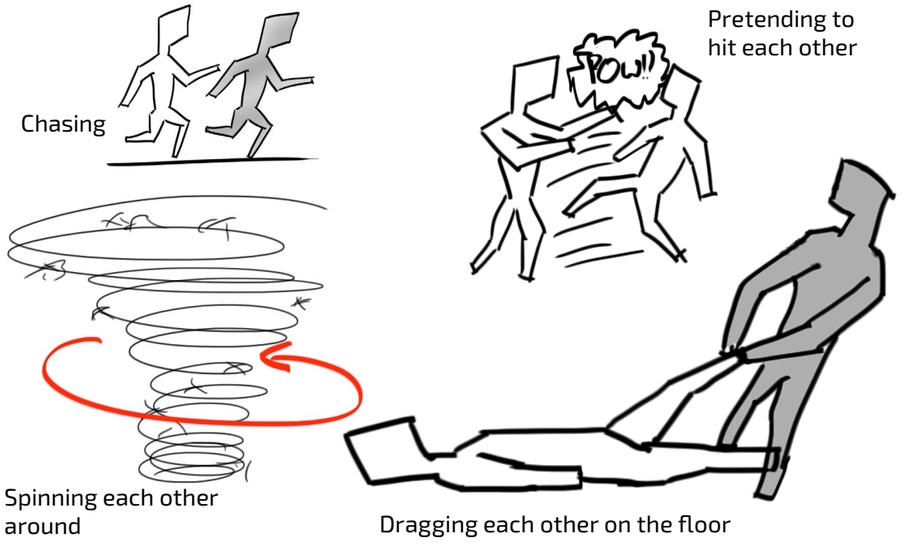


Figure 3;29: Visualization of some of the strategies used by the children to raise each others heart rate.

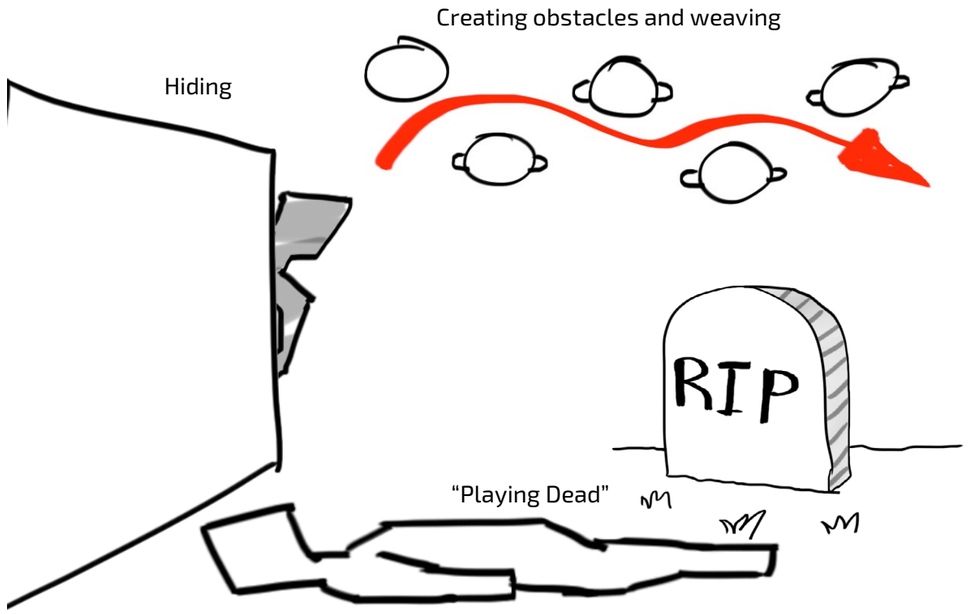


Figure 3.30: Visualization of strategies used by the children to lower their heart rate.

Interestingly scaring was not utilized as a method to increase their opponents heart rate.

In summary here is a list of strategies employed by the children to raise each other's heartbeat:

-Chasing
-Wrestling
-Grappling
-Pushing each other
-Slide tackling
-Blocking each other
-Spinning each other
-Dragging each other around the room on the floor
-Pretending to hit each other.
-Using their opponents personal clothing as bait to chase after.
-Playful teasing to provoke physically active retaliation

(3).What strategies do the children take to try and lower their own heartbeat?

Surprisingly the children were extremely innovative regarding this aspect of the testing, especially the first group of participants. Without explicitly stating, they knew in order to survive as long as possible in the game, they must keep their heart rate low. This was achieved by keeping physical activity to a minimum or do nothing at all by remaining motionless.

Many decided to "play dead" from the start of the test by taking a motionless pose in an uncoordinated manner while lying on the floor, making it difficult for their opponent to stimulate them to move. The foetal position also proved popular in retaining a low heart rate and ensured that their opponents had no immediate access to their body to provoke them to move.

There were limited hiding opportunities within the classroom, but at times participants opted to take refuge and sit in small spaces underneath the window sills.

Some children took a more proactive approach to keep their heart rate low. Some took notice of the red LED on the prototype indicating their pulse and would adapt their activity whether this was walking or jogging at a plodding pace, staying motionless or just swinging their arms or pushing their opponent lightly to prevent them from getting within their personal space and provoking some kind of reaction.

If their opponent were chasing them, they would grab a chair and place it in the chasers track to get themselves some time to have a brief break. In some cases, they simply just ignored the person trying to provoke a reaction from them and continued to doing what they were doing.
Even though some of the children did state breathing exercises as a way of maintaining and lowering their heart rate, it was not entirely evident based on initial observations and the data gathered.

In summary here is a list of strategies employed by the children to lower their heartbeat:

-"playing dead"- lying on the floor
-Sitting
-Staying still
-Jogging
-Creating obstacles (placing chair in their tracks)
-Hiding
-Ignoring advances from opponents
-Pushing opponents away from them

Garment prototype results

(1.)What strategies do the children use to defend themselves and how do they differ from the1st ideate testing session?

The strategies taken for the garment held some resemblance to that of the previous round of testing. There was no distinct difference in the strategies undertaken by both groups of participants for this testing session.

As there was a lot more of the body exposed and vulnerable for tagging, it was near impossible to protect all of the areas. This encouraged more running and chasing compared to the 1st ideate testing session. This brought about more side-stepping, dodging and physically manipulating their body while in motion to avoid getting tagged. Pushes and handoffs were also utilised to try and ensure opponents cannot get within reaching distance of them.

Another strategy was to make the chase as difficult as possible for the tagger. This entailed swift motor coordination from the chaser and change in running line to send the tagger in the wrong direction. Continuing on this subject, weaving between bystanders and the facilitator was also used and in close encounters, they would try to block the chasers running path by placing a chair in their path.

Hiding was also used were the bystanders and facilitators were used as human shields to create a barrier between themselves and the tagger. They also tried to distract the tagger by lying and indicating that something was happening outside the window, hoping that they would turn their focus on that.

In summary, here is a list of defending strategies employed by the children:

-Dodging
-Side stepping
-Weaving between bystanders (those not participating)
-Pushing and hands off
-Change in direction
- Blocking the taggers running line with chairs and personnel.
-Making distractions
-Hiding

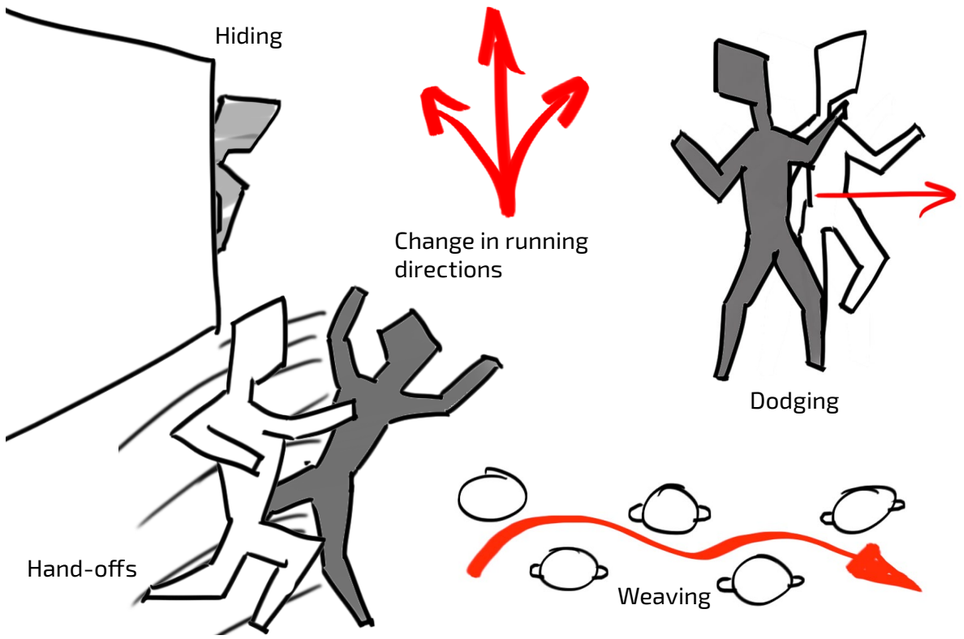


Figure 3.31: Visualization of strategies used by the children to defend themselves

(2). What strategies do the children use to tag their opponents?

Similar to the 1st ideate testing session, slowing down their opponents for a tagging opportunity proved popular by grabbing their lower arms or clothing, and pulling them towards them to get within reach of the garment. Alternatively they chased and directed their opponents towards the periphery or the corners of the room, offering them a slim chance of escaping from their grasp.

If an opponent was too athletic, it was easier to stop them in their tracks and tag them while on the ground. This was achieved through tackling, wrestling and grappling.

Summary of tagging strategies :

-Pulling
-Grabbing
-Wrestling
-Tackling
-Grappling
-Swiping
-Chasing
-Cornering

(3.)Does having the upper body as a tagging location bring about more fluid and natural play?

Based on initial observations and data, it does bring about more fluid and natural play. In general, it held many similarities to that of a regular game of tag and it required the children to be continuously active throughout the test.

(4.) Does the garment accommodate the upper body as a tagging area/location?

From the taggers perspective, the garment does function as tagging area, as it caters and highlights the whole upper body. As a result, it opened up a lot more tagging opportunities when the children were active and in motion. It brought similar tagging strategies from the 1st ideate testing session, however it made it increasingly difficult and challenging for the children to prevent themselves from being tagged in order to protect their lives.

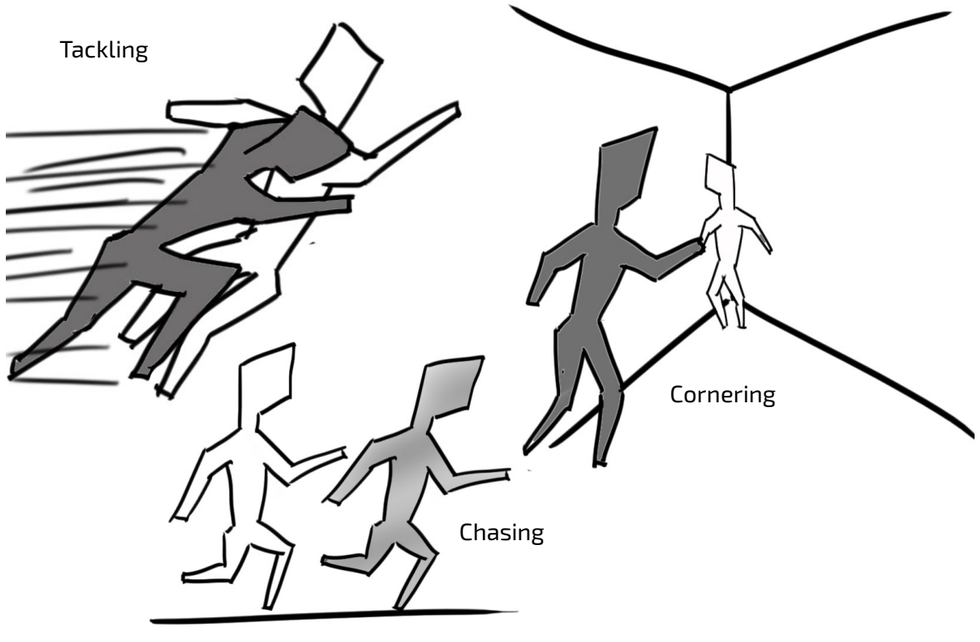


Figure 3.32: Visualization of strategies used by the children to defend themselves.

(5.) Is the difficulty between tagging and protecting lives equal, in the game?

Based on the observations and findings from this testing session and the previous ideate testing session, the balance between tagging and protecting opportunities were not even. Tagging was overwhelmingly easier than protecting oneself from getting tagged. Furthermore, there were more areas to protect on the body and there was no direct way to cover and protect yourself (ie.g the back). Trying to cover and reduce the amount of tagging space available with their hands and arms was not feasible. This was due to the sensitivity of the conductive thread sewed into the shirt. Any contact triggered with the skin or anything conductive material would trigger the buzzer and hence indicated that they were out of the game.

(6.) Is it obvious that the children have successfully tagged an opponent or have been victim of tagging?

With the integration of LEDs and the buzzer, it was immediately obvious that an opponent was tagged. They understood that when they tagged a person, it would activate the LEDs and the buzzer. This also indicated to the tagee that they were caught. However in a scenario where many garments are within the same area, it may become confusing and frustrating trying to clarify who was tagged, etc.

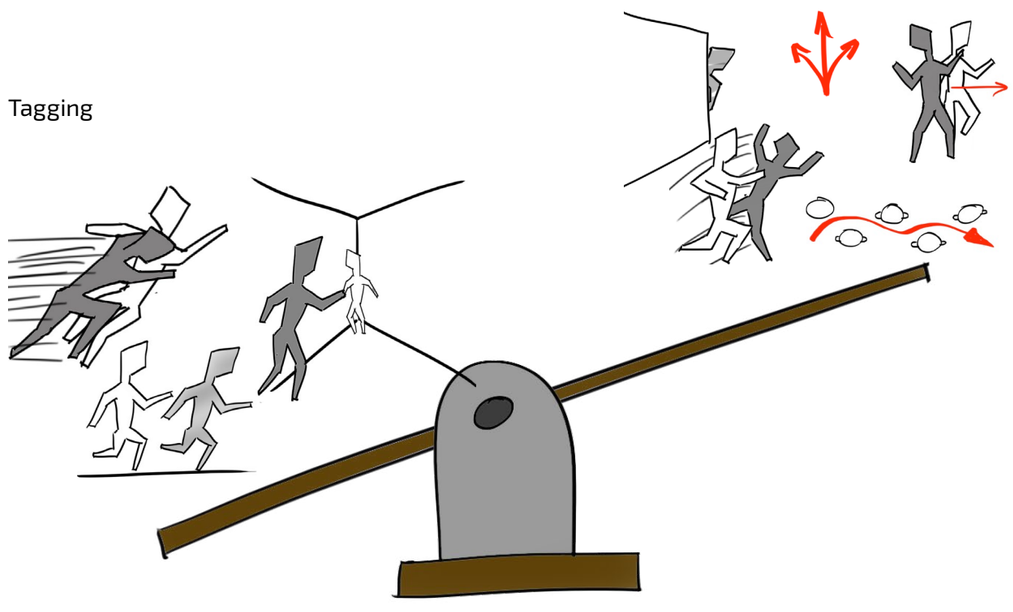


Figure 3.33 The difficulty between tagging and protecting lives are not equal.

	Tagging strategies	Defending strategies	Heart rate raising strategies	Heart rate lowering strategies
Ideate Round 1- Where to place wearable	*-Catching opponents off guard.* *-Getting opponents stationary.* *- Wrestling* *-Grappling* *-Isolate wrist from rest of body.* *-Remove entire tagging unit from opponent's wrist*	*- Hide prototype behind back.* *-Lie on floor, lean against floor, sit on couch, with hand behind back.* *-Play "dead" weight.* *-Cover their prototype with their hands & clothing.* *-Place prototype on inside of arm.* *-Kicking* *-Handstands* *-Spiral kicks* *-Side stepping, Dodging* *- Hiding.* *-Pushing* *-Hands off* *- Using foreign objects to defend themselves .* *-Head-butt's* *- Grappling from behind and swiping tags.*		
Ideate Round 2- Heart rate test			*-Chasing* *-Wrestling* *-Grappling* *-Pushing each other* *-Slide tackling* *-Blocking each other* *-Spinning each other* *-Dragging each other around the room on the floor* *-Pretending to hit each other.* *-Removing opponents clothing.*	*-"Playing dead"* *-Lying on the floor* *-Sitting* *-Staying still* *-Jogging* *-Creating obstacles* *-Hiding* *-Ignoring advances from opponents* *-Pushing opponents away from them.*
Ideate Round 2- Garment test	*-Pulling* *-Grabbing* *-Wrestling* *-Tackling* *-Grappling* *-Swiping* *-Chasing* *-Conering*	*-Dodging* *-Side stepping* *-Weaving between bystanders.* *-Creating obstacles* *-Hiding* *-Making distractions*		

Table 3.4 : Summary of strategies implemented across all tested during the ideate phase of the project

3.8.4 Limitations of study

Several limitations presented themselves for this study.

The testing session was brief in duration with a small number of participants and could not clarify if the same strategies and behaviours would occur over a day long duration.

Testing in pairs made the analysis more efficient, but may not replicate that of a natural play situation of a child where there could be an abundance of friends and peers involved. Various kinds of behaviours and strategies could have been provoked if more participants were involved.

The test location was far from ideal. The classroom offered the only opportunity to test at the school during the given week. This was the only area available to test in within the school building as other classes were using the gymnasium. The playground was offered as a location to test, but it would have required a teaching assistant to supervise. Their presence alone could have restricted the children's creativity for strategies and rebellious potential. It was an aspect I did not want to be limited in the test. The classroom provided a more clinical feel to the test and did not replicate that of a natural area where a child would naturally play. This potentially reduced the number of strategies created due to the lack of props in the setting.
Furthermore the classroom was newly renovated and the flooring was quite slippery, and made chasing each other difficult at times.

3.8.5 Conclusions

It became apparent that the heartbeat element was crucial in the original Bangerik concept. It brought about an array of strategies for raising, influencing and controlling one's heartbeat. The heartbeat test proved to be the more fun challenge for the children, and it exhibited how crucial it was for the previous concept. Based on what was observed, it is an aspect that should be integrated into the final prototype. Feedback should be optimised further to indicate when the heart rate is low, increasing/decreasing and when it is high. For the sake of ethics, this should be achieved discretely as not to reveal much information on their current health to others. Furthermore, the threshold for a high pulse should be calibrated per child, as this varies per child based on their age and size.

As stated the garment did not provide an even amount of difficulty between tagging and protecting lives. Tagging was a lot easier due to the tagging space allocated by the garment, than trying to protect from getting tagged. The "sweet- spot" for the design of the concept potentially lies somewhere between the garment as a tagging platform and that of the previous testing session with multiple separate body parts used as tagging locations. This should be further investigated and determined for the final prototype. Potentially reducing the amount of space available to tag on the body, could create a more level playing field between tagging and protection strategies for the children, hence making the game more enjoyable for them. However it could be interesting keeping some tagging areas exposed to tagging. With more tagging areas exposed and fewer body parts to cover, this may encourage the children to utilise strategies to lower their heartbeat and reduce their risk of getting tagged.

The feedback from the garment showed potential and should be further optimised for the children to avoid confusion when there are more players involved and if the game is played over a day. Personal feedback per player should indicate when they have been tagged or lost a life. The inner components and hardware of the garment should be reduced in size and less cumbersome, as they made moving awkward at times.

With regards to testing, conducting the testing in pairs was the right decision, due to the space available and making analysis process more concise. However, bringing the whole group of 6 or 5 for each testing session was not ideal as the children wanted to be continuously involved in the testing and would grow impatient waiting for their turn. Some entered the play area and in doing so were distracting those participating in the test. For the next test, the children should be taken in pairs from the classroom towards the testing location. And preferably the testing location should be taken into account for and reflect that of an environment were children would normally interact and play.

Ideally, the next prototype should operate as a pair as some of the children do not like the connotation of "being it" and being nominated to be the tagger/chaser for the test.

04 Make

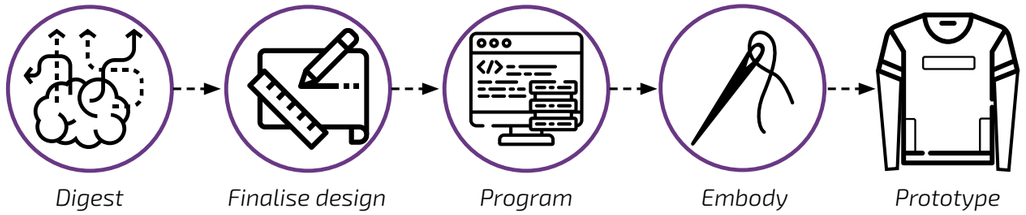


Figure 4.1 : Overview of make phase

4.1 Overview

This phase consisted of understanding the findings of the previous phase, so informed decisions could be made for aspects of the final design could be made. The primary issue to be determined was the form, followed by the visual behaviour and the aesthetics the design would take. A selection of these factors are embodied into prototypes to cater to the research focus and questions for the pilot study outlined in section 5.4.1

4.2 Goals

This phase aimed to convert the findings of the ideate phase into test worthy prototypes for the pilot study, that best represents the behaviour and aesthetics of the desired concept as closely as possible in terms of the interaction and the feedback methods it accommodates.

4.3 Defining pilot study focus

With the conclusions for the ideate phase in mind, the research aspects for the pilot study are defined, so suitable prototypes can be made to gather answers for the specified research question outlined in section 5.4.1.

Based on the findings obtained, the aspects highlighted in figure 4.2 were chosen as the primary focus points for the pilot study. The reasoning for selecting these aspects are as follows:

Strategies

During the ideate round 2 testing session, strategies of raising and lowering heartbeat (see 3.8.3) were investigated and concluded that the heartbeat factor was a worthy element to be integrated into both the prototype and the final concept. Furthermore tagging and defending strategies were investigated in both rounds of testing during the ideate phase through separated tagging locations on the upper body and the whole body as a single tagging location. The elements mentioned have not been tested

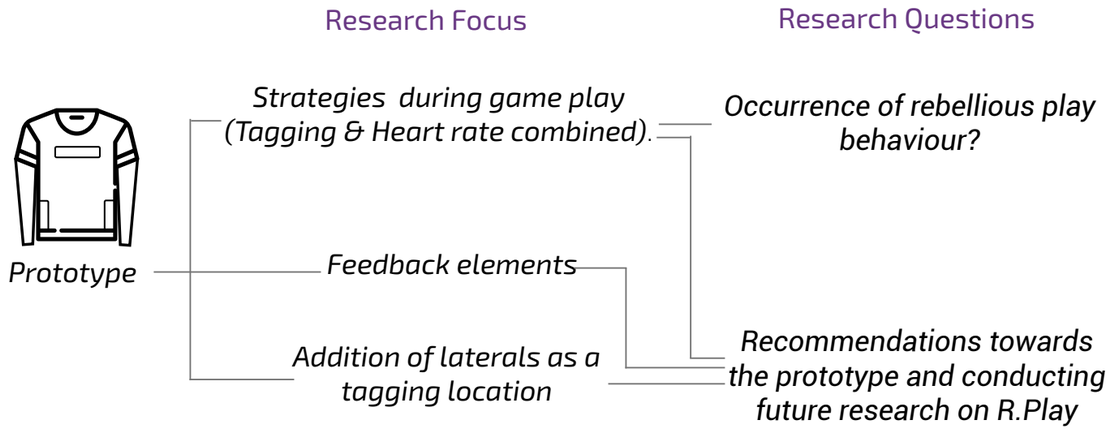


Figure 4.2 : Defining Research focus areas for prototype to be used in pilot study.

together in an integrated form and would be useful to do so as it could potentially affect the game mechanics of the concept. Potentially combining the heartbeat and tagging elements into one form could add an extra layer of complexity to the game, keeping the children interested in the game for longer.

Feedback

The feedback integrated into the previous prototypes were simple in their behaviour consisting of flashing LEDs and buzzer sounds to indicate when the heart rate threshold has been reached and to indicate when a player was tagged. The feedback aspect was one of the original research gaps established early in the Ideate phase (see section 3.3.2). However, it was not thoroughly examined or investigated during the previous test rounds. The visual behaviour needs to be both optimised and integrated into the prototype, to indicate when their heart rate is over the threshold and when a player is tagged. This is further discussed in section 4.4.3.

Laterals as a tagging location

The core tagging areas established during the previous testing rounds were the upper arms and the chest. However the children can easily cover these areas by crossing their arms across their chest and resting their hands on their upper arms. The second round of testing brought about the suggestion of having several separate tagging locations on the upper body. Some tagging areas still need to be exposed to investigate if the children lower their heart rate as a defence strategy. The laterals were chosen based on observations from the first testing session (see 3.6.3), as these areas proved to be a popular area for grabbing and wrestling to slow players down while running to try and tag them. The location also ensures that other tagging areas remain vulnerable as they all cant be physically covered and protected by players during the game. Furthermore the laterals can be accommodated on a garment.

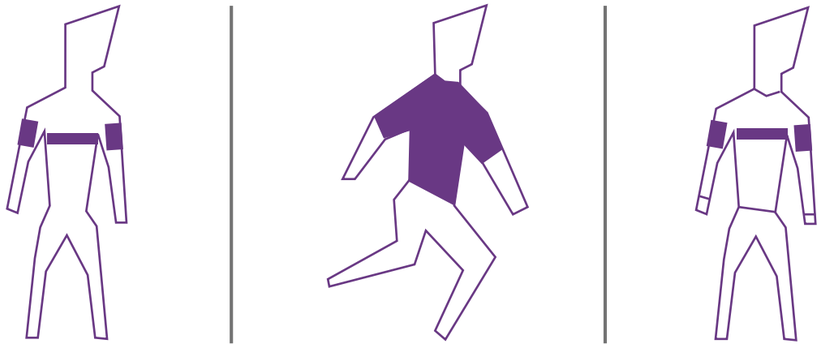


Figure 4.3 : Defining Research focus areas for prototype to be used in pilot study.

4.4 Finalising the design

4.4.1 Embodiment

With the research focuses in mind, clarity was needed on how to accommodate them best during the testing session. Whether this is having separate tagging areas (Ideate round 1), a garment covering the entire body as a tagging area (Ideate round 2) or a combination of both with various tagging locations exposed on the upper body (see figure 4.3). It is worth noting that the combination approach was not addressed or previously tested during the ideate phase of the project. Hence the potential of the approach is based on the insights gained from the tests during the ideate phase and the author's backing & assumption. The strength and weaknesses of the previously tested separate entities and garment approach are recapped in table 4.1.

Strengths	*Weaknesses*
Separate tagging areas	
- Offered an abundance of strategies to tag and protect lives. -Encouraged the children to try less traditional strategies to protect their lives	- Tagging area made movement awkward. -Tagging increasingly difficult compared to protecting lives. - Attaching the prototype to the children was awkward. - Play became intermittent and stagnated as the game continued.
Garment-Whole upper body	
- Offered an abundance of strategies to tag and protect lives. -Encouraged the children to try less traditional strategies to protect their lives	-Tagging was overwhelmingly easier than protecting lives. -Garment area was too exposed to tagging. -Children could not cover the entire space to protect their lives.

Table 4.1 Strengths & Weaknesses tagging forms

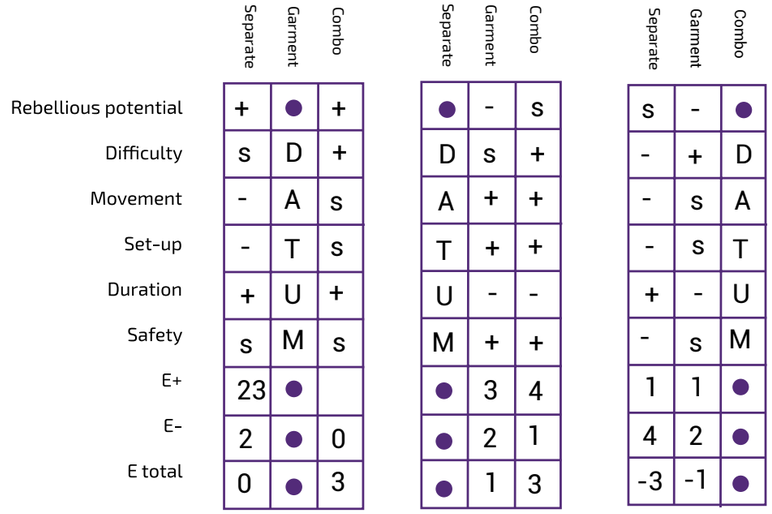


Figure 4.4 :– Datum method for separate/combo, garment/combo , separate/ garment

Criteria	*Explanation*
1. Rebellious Potential	Providing the children with opportunities to be rebellious with the strategies they may implement
2. Difficulty	-Providing similar difficulty levels between tagging others and protecting lives.
3. Movement	- Allowing the children to freely move while playing the game.
4. Set-up	-How easy and efficient it is to attach the prototypes to the children.
5. Duration	-How long the game play could potentially last for. (Based on how difficult it is to tag protect lives, etc.)
6. Safety	-Holding the components of the prototype in a secure manner. Ensuring that the prototype stays attached to the body during testing and minimizing the risk of a child getting hurt during game play.

Table 4.2: Explanation of criteria applied for evaluation methods

Furthermore, Datum method (see figure 4.4), a Harris profile and Weighted objectives were performed to determine a preferred embodiment direction for the concept. The outcomes for the latter two methods can be found in appendices K.

The criteria applied for the methods previously mentioned are ranked in importance, explained and outlined in the table 4.2.

The combination approach also proved favourable upon completion of the datum method, having a superior advantage over the other approaches with regards to the difficulty of the game, movement and set up.

In conclusion, upon evaluation of the three methods applied, it was decided that the combination approach was the preferred direction for embodiment. This was due to the concept dominating across the evaluation methods and exhibiting positive scores against the majority of the criteria outlined.

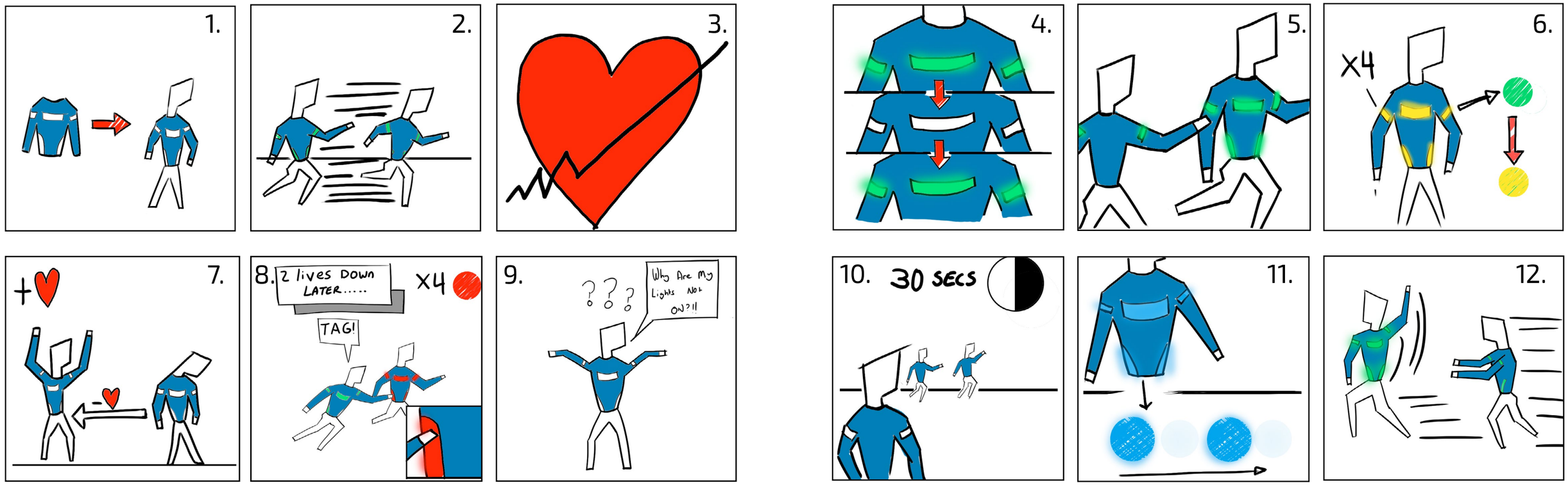


Figure 4.5 : Storyboard of X-eo concept

4.4.2 The X-eo concept

With the research focuses in mind, clarity Based on the gathered insights, the X-eo concept was born. Similar to the bangerik concept (see section), X-eo is an interactive, wearable tag game that offers the children the opportunities to steal lives from each other by raising other player's heart rate. X-eo derives from the Latin word "Exeo", that translates into English as to leave, escape or cross. In the context of this game, it is the desire for the children to escape their norm and „cross the line" to explore their behavioural boundaries. For a full description of the concept operations, please see section 4.4.3 and figure 4.5.
X-eo consists of a tight-fitting Bluetooth enabled garment with an integrated heartbeat sensor and five illuminated tagging points located on the upper arms, chest and laterals.

4.4.3 Concept behaviour

The core idea is that the children, their friends and classmates would wear the garments and continuously play the game over a day-long period. However before playing the game, the shirt needs to be calibrated with the child. For calibration, it needs to be once off connected to a smartphone via Bluetooth so that a player profile can be applied to the garment.
The child is then required to wear it for a period to obtain their average heart rate value, so their high heart rate threshold can be calculated and set for the game.
Once calibration is complete, the child can participate in the game.

As mentioned previously the primary goal is to raise their opponent's heart rate by any means possible to steal their lives, whether this is through chasing or implementing others strategies similar to those outlined in section 3.8.3.

Each player begins the game with three lives. The player's life status is illuminated on the touchpads on the garment, based on a traffic light system. Green represents a full bill of health with three lives, amber with two lives and red meaning they have a single life remaining. (See figure 4.6).

When a player's heart rate has reached their threshold, the touchpads will begin to illuminate with a pulse animation to indicate that their life is available to be stolen. The animation will continuously run as long as their heart rate is over the threshold.

When a player is tagged via touchpads, they will flash four times to indicate their life was stolen before changing to the next colour in the system.

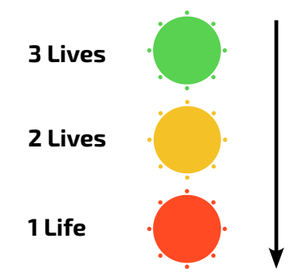


Figure 4.6 : Traffic light concept integrated in concept

4.4.4 Aesthetics

In order to get a sense of the aesthetics for the concept, the author spent a few hours watching children's TV programmes to gain a visual sense of what the children were immersing themselves in. The majority of the programmes observed had a superhero and futuristic vibe to them, with characters wearing a uniform of some sort (see figure 4.7). The uniforms fitted tightly around the character's body, defining their upper torso. This was accompanied by a sharp contrast in colours that highlighted different parts of their bodies.

For the concept it was decided to replicate this, by having a neat fitting garment and using simple shapes for the tagging areas. The illumination of the tagging areas would contrast to the material of the garment to give it a futuristic, superhero vibe (see figure 4.7.1).

It is desired to have an energetic, fearless mood to it look, similar to the superheroes they admire. It corresponds to the core of the game outlined in 4.42, that they should not be afraid of exploring their behavioural boundaries.

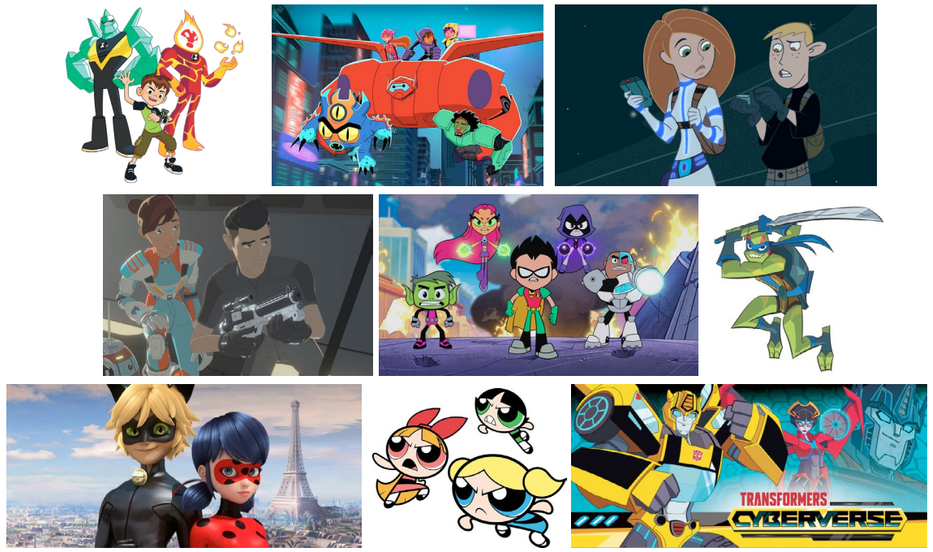


Figure 4.7 : Moodboard of popular children's TV shows

Figure 4.7.1 : Desired look of concept.

4.4.5 The difference between the concept and the prototype

As stated earlier in section 1.1, one of the goals of the project was to create a test worthy prototype for the context of the pilot study. Unfortunately, it was not feasible to develop a prototype fully resembling the features of the X-eo concept as previously described in section.

However, a selection of features from the concept could be translated into the prototype through a "minimal viable prototype" approach. The tagging, heart rate and visual behaviour were elements selected for integration into a prototype of this sort.

The communication element of the concept with the transferral of lives between players was dropped for prototyping. This decision was primarily due to time constraints and programming knowledge at the author's disposal.

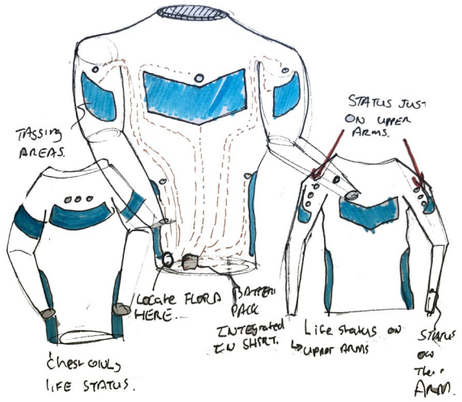


Figure 4.8 Initial sketches of prototypes.

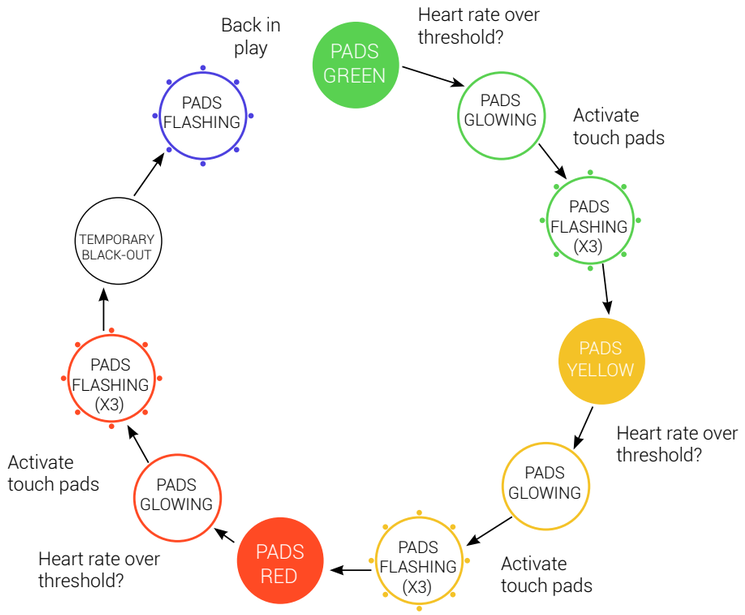


Figure 4.9 Visual of desired prototype behaviour

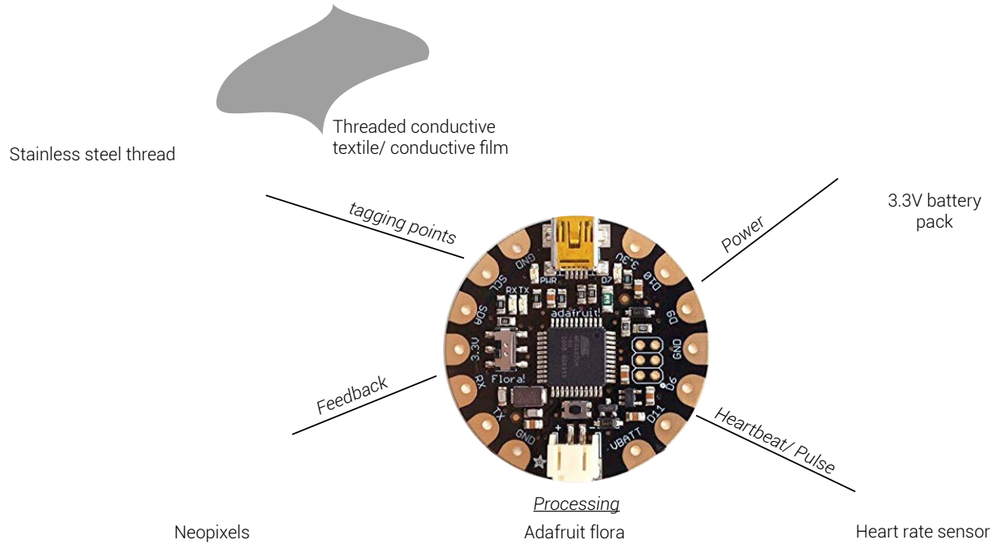


Figure 4.10 Visual of desired prototype behaviour

4.4.6 Prototype components

To accommodate the behaviour previously described in 4.4.3, the components in figure 4.10 were selected to do so. The reasoning for the selection for the core components was identified in 2.7.3.

The Flora board by Adafruit was the preferred processor to operate the behaviour of the prototype, as it's designated for wearable projects due to its discrete size and weight. The flora also has a capacitive touch function that can accommodate the tagging element of the game. This can be achieved by sewing conductive textile touchpads on the prototype and sew the connection to the board using conductive thread.

The visual behaviour will be performed on Flora neopixels by Adafruit. These are compatible with the flora board and can also be controlled and powered using conductive thread. The neopixels are powerful and are capable of running simple animations.

The garments were brought pre-made from a sports department store. The sizes of the garments reflect the ages of the children participating in the testing session. A compression fit shirt was preferred as it allowed for flexibility in terms of accommodating the different body proportions of the test sample.

4.4.7 Embody- Making the prototypes

The tagging pads were first sewn onto the upper arms, chest and laterals of garment and all linked together into a series circuit using conductive thread (see figures 4.12) The dimensions for these tagging areas can be found in appendices M

The neopixels were applied to the upper arms and chest, as these areas are visible to other players during play. Furthermore adding more neopixels above the laterals would have made the sewing process more problematic. The conductive thread was sewn between the neopixels and attached to the Flora board. All thread connections to the neopixels were sealed with nail polish to keep them securely attached to the boards. (see figure 4.11).

Wired connections such as the resistors and the heartbeat sensors were soldered on the Flora board prior to being sewn into the shirt. The connections were all tested and troubleshot before being attached to the Flora board and integrating within the garment.

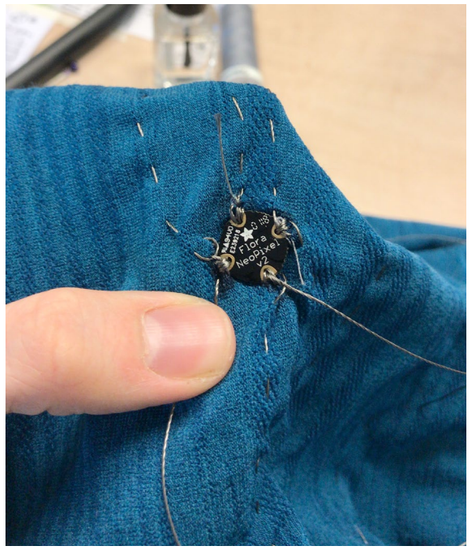


Figure 4.11: Sealing neopicels with nail varnish

Figure 4.12 Sewing touchpads onto garment

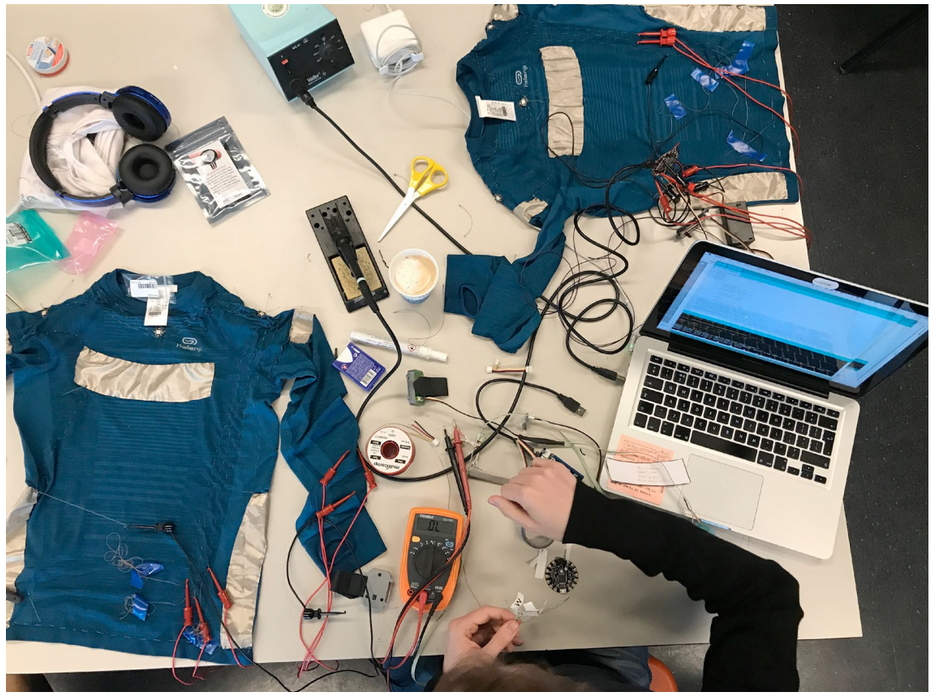


Figure 4.13 : Installing components and soldering wires to flora board

Figure 4.14: (Left) completed prototype on mannequin and (right) on child.

05

Evaluate

5.1 Overview

The final phase of the project consisted of preparing, conducting the pilot study with the prototypes in the context and evaluating the obtained data. This continues to recommendations, an evaluation of the methodology applied and reflections in regards to the prototypes and conducting further research with them.

5.2 Goals

Several goals presented themselves for the phase of the project.

The first being organising the pilot study and defining research questions that addressed aspects of the X-eo concept that still needed to be clarified.

This was followed by establishing a means of identification and operationalisation of the children's play behaviour during the pilot study. A meeting with child psychologist, Lieselotte van Leeuwen of the University of Gothenburg was arranged to do so.

From here relevant conclusions and recommendations could be made for future research and design activities with the X-eo concept.

5.3 Evaluating rebelliousness

Upon discussion with Lieselotte van Leeuwen, the following factors were established to identify rebellious behaviour:

•The level their rebelliousness occurs on.

•The decision points when the child opts to behave in such a fashion.

At specific moments during the pilot study, the children could interfere with and be rebellious towards many kinds of rules during play. A framework of rule type hierarchy was formulated and is as outlined in figure 73. The goal is to use this framework to establish the level of rebellion by investigating the rule types violated during play. The rule types are as follow:

•Societal/conventional rules

•Contextual rules

•Relationship rules

•Game rules

•Game mechanics & operations

Societal & conventional rules refer to the general standards of conduct accepted and adhered to by society daily. They are the foundation for the construction of other rule sets.

Contextual rules apply to all contexts such as home, school environments and determined by stakeholders of the children including parents, guardians and teachers. The rules enforced often reflect on societal rules to instil the children with desirable behaviour and practices for when they are outside the given context.

Relationship rules refer to the dynamic between people where terms and boundaries are negotiated and defined between both parties. These negotiations can take the form of outlining rules and what is acceptable between them. Hence the children can decide to rebel against each other and explore their boundaries or rebel together against the rules.

The game rules are preprogrammed and outline what is acceptable within the play frame. These rules do not correlate with societal and contextual rules sets.

Moreover, game mechanics determine the internal and physical operations of the game and can be tampered and manipulated during play to gain an advantage over their opponents. (e.g. adjusting wires, sensors and components, etc.).

It was advised to triangulate the data observed after testing, by asking the participants indirectly about their experience of performing rebellious acts and breaking the rule types within the framework.

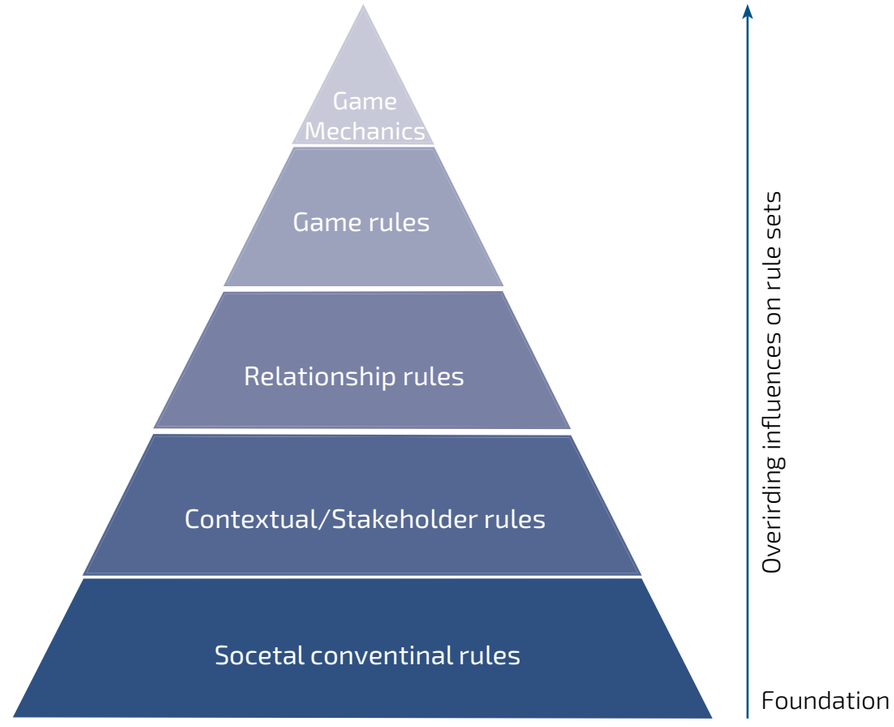


Figure 5.1: Hierarchy of rules framework

5.4 Pilot study

5.4.1 Research goals

With strategies, feedback and the laterals as a tagging location identified as research subjects in section 4.3, the following sub research goals were established for each particular theme to answer the main research questions.

Strategies

1.What strategies to do the children use to raise each others heartbeat?

2. Do the children use lowering their heart rate as a strategy and if so how to do they do it?

3.What strategies do the children take to tag each other?

4. What strategies do the children take to prevent them from getting tagged to protect their lives?

5. Are any of the strategies implemented rebellious in their nature?

Visual Feedback

1.Do they understand when their heart rate is high and makes them vulnerable to others for tagging?

2.Do they understand losing one of their lives?

3.Do they understand when they have lost all their lives and are temporarily out of the game?

4.Do they understand when they are they are allowed back into the game?

Laterals as a tagging location

1.Do the children aim to tag the laterals during play?

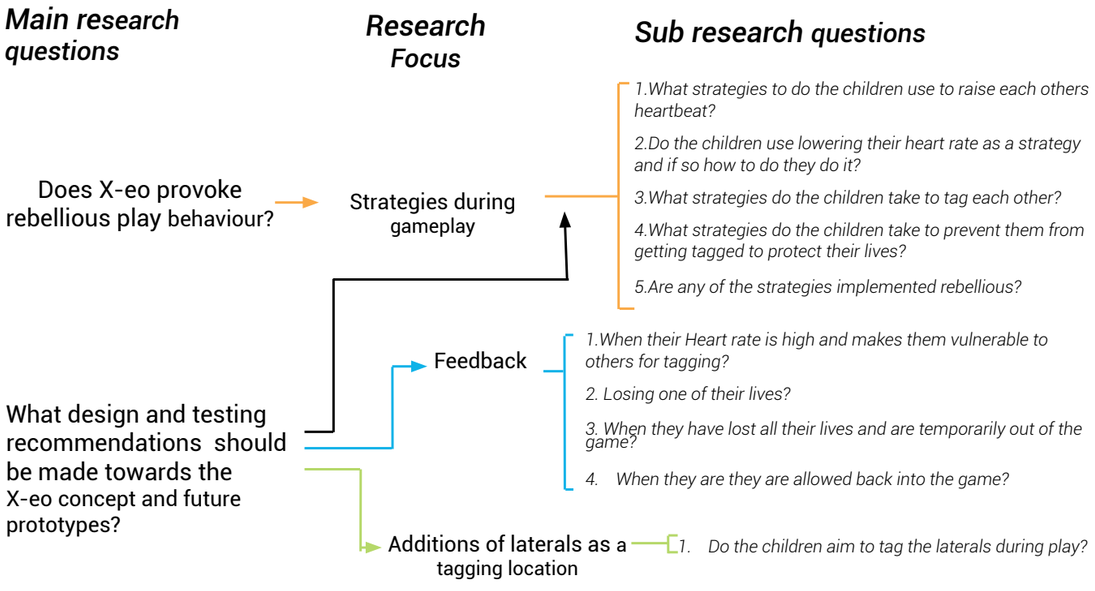


Figure 5.2 : Pilot study over view

5.4.2 Pilot study setup

The testing was conducted with the same participants that participated from the 1st round of testing. The testing took a similar format to the last test conducted during the make phase with the children testing in pairs.

The context for this test was the yard within the school premises,(see figure 5.3). This was the only area available for testing due to class schedules and the unavailability of the gymnasium and other rooms within the school building. As the schoolyard was quite large, it was decided to cordon off a small section of the area for the test. The play area for the test was marked out applying tape to the ground and approximately measured 12 x 8m. This was done to make the gathering of data, making observation easier.

The testing was estimated at approximately 20 minutes per pair and took the following schedule:

•The children were welcomed to the session and thanked for their support and participation. It was outlined that they are free to leave the testing session at any time at their discretion. (1 minute)

•The children were given a recap of the last session and the implications it had for the current testing session in terms of the prototype and what they were participating in. (2 minutes)
•The children were given a brief overview of the game to ensure that they understood it. (2 minutes)
•Both children were provided with a garment and assisted by the facilitator to put it on. Before powering the garments on, the rules and the physical boundary of the game were outlined. (2 minutes)

•The heart rate sensor utilised in the prototype will be adjusted accordingly by the facilitator. This is to ensure that an accurate measurement is provided from the surrounding area of the forefinger/ wrist. All the components were inspected to ensure that they are working before play. (3 minutes)

•The children then approximately played for a total of 6 minutes.

•The children then participated in a causal debrief session where the children were asked about instances observed in the session, as a form of triangulation for the gathered data. (5 minutes)

Furthermore, the data was analysed in a similar fashion to the previous test, with the footage being viewed in a systematic manner with timestamps and notes taken. In addition the hierarchy outlined in 5.3 was transferred into to a grid format, to classify rebellious play behaviour that. These instances were noted, time stamped and assisted by quotes from the children when possible. Examples of these grid sheets can be found in appendices M. Summarised examples of these classifications can be found in table 5.1 in 5.4.3.

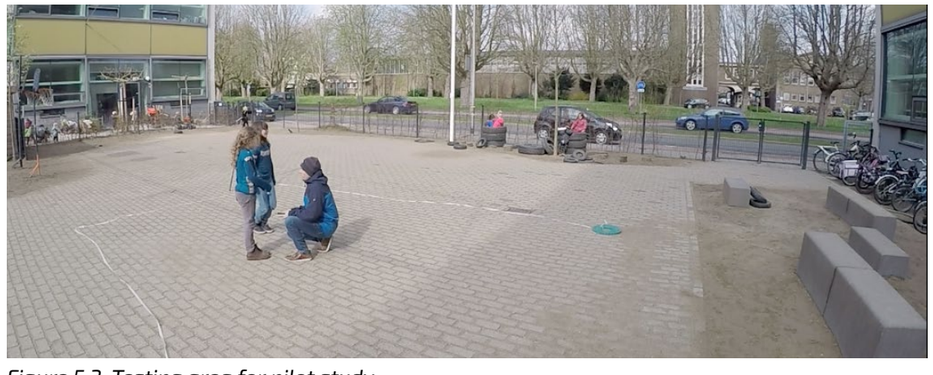


Figure 5.3 Testing area for pilot study.

5.4.3 Results

Strategies

1.What strategies to do the children use to raise each others heartbeat

The children implemented a range of strategies to raise both their opponent's and their own heartbeat throughout the session. The strategies varied per testing couple with brasher unorthodox strategies being enforced by the male participants compared to the females throughout the session. The majority of participants used physical stimulation to raise their opponent's heartbeat.

Interestingly some of the children decided to raise their heartbeat without being threatened or provoked by their opponent to do so. They achieved this through performing physical activities such as jogging on the spot, jumping jacks, spinning, running around the peripheries of the playing area and dancing. As they knew the testing session was in duration, there was an urgency to get active and raise their heartbeats immediately so they could start tagging each other straight away.

On par with the ideate round 2 testing sessions, scaring was once again not used by the children to raise each other's heartbeat.

List of strategies utilised to raise heart rate;

•Chasing
•Jogging on the spot
•Physically teasing each other
•Chasing each other from side to side of the physical peripheries of the play area.
•Running around in circles.
•Spinning around (Individually).
•Screaming and shouting at each other.
•Making themselves look physically look bigger.
•Jumping jacks
•Running from corner to corner of the physical peripheries of the play area.
•Running around the physical peripheries of the play area.
• Dancing (Individual)

2. Do the children use lowering their heart rate as a strategy and if they do so, how to do they do it?

Based on the data obtained, this strategy appeared to be less utilised in the children's collection of tactics and strategies across the whole pilot study. It appears that it never crossed their mind when they were faced with a dilemma of attacking or defending within the game. This was primarily the case with the defending aspect of the game, where they had the choice of actively (Increasing their heart rate) or passively defending (lowering their heart rate). It seemed that the children wanted to be continuously active and chase each other throughout their respective testing sessions. During the rare occurrences of the children lowering their heartbeat, pro-active approaches were preferred such as walking, jogging and strutting.
Passive approaches were less practised throughout the session, with staying still and taking deep breaths being the only evidence of doing so. The most unforeseen strategy to arise from this approach was a face-off scenario where both competitors would keep their distance and stay still for a short period, then waiting until one of them gets active and start chasing them again.

List of strategies utilised to lower heart rate:

•Walking

•Staying still and having a face off.

•Jogging

•Hands on hips and breathing

•Strutting

•Having obstacles in their running lines and get a chance for a brief break

Figure 5.4 Child doing orthodox pose

(3). What strategies do the children take to tag each other?

The tagging strategies implemented by the children were dominated by proactive, energetic approaches as demonstrated by the children in chasing and swiping at each other throughout the testing sessions. Some children decided to hold a central strategic position in the middle of the play area and forcing their opponent to remain at the periphery in the hope they can trap them there and tag them. Alternatively they would wait until their opponent is fatigued and tired from the running forced upon them, then intervening for a tagging opportunity. Cornering proved to be a popular approach to starve the opponent of space to try escape from their grasp.

Furthermore, some children took a more physical and aggressive approach to their strategies. These strategies took the form of wrestling and grappling manoeuvres as previously mentioned in section (). The hard terrain of the testing context did not deter some children from taking matters to the ground if required to tag their opponent. This consisted of grabbing their opponent's hands and arms, wrestling, grappling and pinning them down to reach their desired tagging location.

Surprisingly some of the children were quite brave by squaring up and getting within reach of their opponents, by manipulating their body to take the form of an "orthodox stance" as exhibited in many combat sports. This stance allows the children to defend themselves by raising their weaker hand in front of their torso to fend and then tag their opponent using their more dominant stronger side of their body accompanied by their stronger hand.

List of tagging strategies:

•Chasing opponents to the periphery of the play area.

•Swiping with their arms

•Slowly creeping up on each other

•Square up/Orthodox fight pose and then strike for the tag.

•Push/ handoff to the chest

•Cornering

•Grappling

•Wrestling

•Spinning around

•Grabbing victims hands

•Pushing them down to the ground

•Pinning them down to the ground and ensuring that they cannot move

•Extended Reach

•Swipe and twist

•Circling and waiting for their opponent to make a mistake or first move

•Jumping jack swipes

•Karate hit/fend

(4). What strategies do the children take to prevent them from getting tagged to protect their lives?

Similar to the tagging strategies previously outlined, the children also favoured a more proactive approach to protecting their lives. As mentioned in research question 2, in extremely rare cases did the children take the passive route to protect themselves from being tagged by controlling and lowering their heartbeat.

The strategies in their nature were predominantly active with running away from the tagger being the most preferred approach by the majority of the children throughout the session. Sidestepping, dodging and spinning away from their opponent also proved popular. Some children opted to cover as many tagging areas as physically possible with their arms and hands, similar to the strategies shown in the 1st round of testing during the iterative design loop during the Ideate phase of the project.

The most enticing strategies arose when the children decided to be more physical and rougher with each other. These ranged from pushing, shoving, wrestling and kicking. Handoffs and swiping at their opponent's hands also proved effective in preventing their hands from reaching their tagging locations.

Furthermore, some children created smart strategies to protect themselves. One example of this involved pushing their opponent over the periphery of the play area, and in doing so they were not technically within the "physical play" frame meaning that they could not be tagged. The goal then was to prevent them from entering the play area so they could not get tagged within this space.

There were no props as such provided for the children within the testing context to fend and keep their distance from the tagger. One child decided to roll down her sleeves over her hands and swing the excess material at the tagger to try to defend herself and distract the tagger from placing a hand on them.

Some children decided to manipulate their prototype to protect their lives. The children discovered by just physically adjusting the lights on the garment, they would change colour and extend their lives. Some adjusted the heartbeat sensor on their index finger by reversing it to the bony side of their finger, hence preventing it from detecting blood flow through the tissue.

- ***Side stepping***
- ***Change in running direction***
- ***Creating obstacles in their running trajectory(jumping over blocks, tires, etc)***
- ***Running from side to side***
- ***Trying to hide***
- ***Dodging***
- ***Raising legs while lying on ground to protect torso while lying on the ground***
- ***Pushing opponent away***
- ***Pushing opponent across the periphery of the play area***
- ***Swinging elbows to escape the grasp of the tagger***
- ***Fake boxing***
- ***Not letting opponent back into play if they cross the periphery of the play area***
- ***Covering tagging areas with hands***
- ***Pulling down sleeves of garment and swinging them to fend off the attacker.***
- ***Blocking opponent's hand as they try to reach for the tagging areas***
- ***Kicking***
- ***Hiding behind tires and the facilitator***
- ***Spinning away from opponents***
- ***Sudden burst of speed while running to avoid getting before the attacker reaches their area.***

(5). Are any of the strategies implemented rebellious in their nature?

Based on the rebellious hierarchy previously outlined in the setup in 5.4, some of the strategies implemented were indeed rebellious and were well distributed amongst each category described as outlined in table 11 below. The majority of these rebellious strategies and actions arose from the tagging element of the game while the children were trying to tag each other and protect their lives. The most extravagant instance to arise was one child pinning another child on the ground and play biting and licking their face.

Based on observation the most violated category within the hierarchy were the actual rules of the game, of not hurting each other and staying within the defined play area. This was followed by context and conventional rules as they are closely interrelated to each other. Some examples are provided of how the author classified the behaviours are outlined in table 5.1 below for research clarity.

The majority of the children openly admitted that they partook in acts of rebelliousness during their respective sessions immediately after in a debrief conversation. A full list of their quotes obtained from the debrief can be found in figure 5.6, located on page 122.

Some were reluctant to admit it but was made apparent by their lack of communication, facial expressions and sniggering laughs. They understood what they did was naughty as such, but they could not precisely define why it was. However, some children were quick to come up with reasoning on why their behaviour was appropriate and acceptable at that time

Shouting in opponents face	Children smiling and having fun.	This behaviour was determined as acceptable within the boundaries of the children's relationship and game rules, but unacceptable under societal and contextual rules . However within the relationship, it was fine as the relationship was still intact and the children were laughing and having fun. Outside of the play frame, this kind of behaviour is viewed as unruly and rude.
Wrestling	Visual cues from playground guard.	Wrestling was classified to violate contextual and societal rules. The behaviour was acceptable within their relationship and game rules as there was no specific intention to hurt each other. However before the test, the teacher stated that this kind of behaviour would not be appreciated on the playground. This was reinforced by the guard on duty on the playground and signals this to the facilitator as the children were frantically wrestling on the playground. The facilitator has to intervene as an outward authority to prevent them from getting into trouble with more stakeholders.
Throwing each other to the ground	Child saying "Ouch"	Based on observation this behaviour was interpreted as not acceptable amongst societal, contextual, relationship and game rules. The child in question was thrown towards the hard terrain of the ground. It was hard to determine whether there were intentions to physically hurt his opponent. Furthermore, the behaviour was difficult to classify as the child appeared to be temporarily hurt but immediately returned to play after it.

Table 5.1: Classifying behaviour examples

Behaviours not accepted within framework:

-Licking and biting
-Scratching
-Kicking
-Verbal threats
-Throwing each other to the ground
- Swinging elbows
-Punches

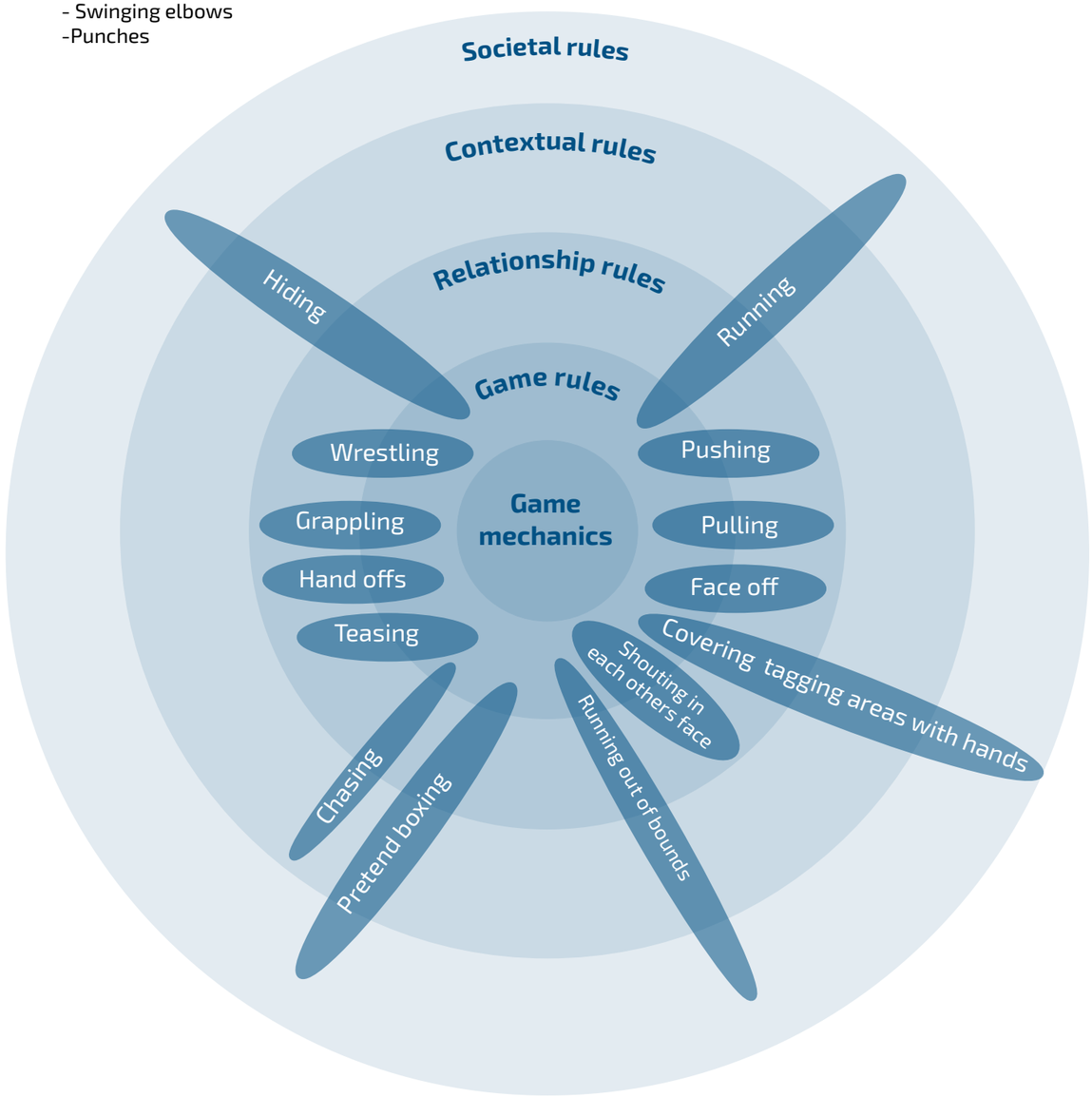


Figure 5.5 : Behaviours accepted within the hierarchy of rules frame work.

“Where you cheating here?”

““No!! I just did this to light it up” (Demonstrates hitting the neopixels on the shirt to change their colour).

“She was chasing me so much and I couldn’t get her she kept running away, I don’t know. Maybe running over the line was naughty, I don’t know maybe….”

“Wrestling and stuff is naughty, I did it because he was fighting with me for no reason…..and I will punch you “(looking at opponent)

“Yeah he was naughty too, he would not listen to me”

“I was naughty because I liked the costume”

“Yeah she was kicking, hahaha”
“I was defending myself like that” (demonstrating a kick)”
“ You shouldn’t do it because you can hurt each other”
“ I did it because I am strong and I just want to kick her in the face”
“I want to kick you too”
“ I do too, but I don’t want too because she is my friend”
“But if she was a stranger trying to attack me, then I would really kick her in the face”.

“ He scratched me” (points at a small cut on arm)

“ No”

“Yeah”

“Did you mean too?”

“ Not really, but a tiny bit, because I could get to him”

“Yeah wrestling, hurting people, you know this is bad because some people get bleeding and have to go to hospital”

“Is wrestling naughty/”

“YEAH”

“Why?”

“Dunno?”

Figure 5.6 Quotes from children during debriefing with regards to things they performed during the testing session

Visual Feedback

1.Do they understand when their heart rate is high and makes them vulnerable to others for tagging?

At times they completely neglected the cues and just attempted to tag their opponents regardless of the displayed status. If the children were within reach of each other, they could establish that the neopixels were glowing and that a life was available to be stolen.

2.Do they understand when they have lost one of their lives?

In principle, the majority of the children understood the connotation of the traffic light system, with green being positive and red being negative. However this was not entirely clear with the data gathered as the sunny weather conditions made it hard to determine their status at times. It required a closer inspection of their opponent's garment to clarify this.

(3). Do they understand when they have lost all their lives and are temporarily out of the game?

The children did assume that when the neopixel LEDs were not emitting any colour or animation, they thought they were out of lives and presumed "dead". However this was mainly due to technical issues with the prototypes due to the rigorous use they endured through the session. Furthermore, throughout the testing the games never naturally reached as far as this point, hence it cannot be identified whether this was the case for the children during gameplay.

(4).Do they understand when they are they are allowed back into the game?

Similar to the previous research question, the children assumed as long as the neopixels were displaying a colour of any sort that they were still in the game as such. The time spent playing was not long enough to reach this point of the game to clarify this aspect.

Laterals as a tagging location

1.Do the children aim to tag the laterals during play?

The laterals were surprisingly not used as much as assumed, as the children opted to tag the higher locations of the upper arms and chest on the garment. This was especially the case when the children were chasing each other. However if the children were confronting each other in a face-off situation, some would try to swipe at either of the laterals.

5.4.4 Limitations of study

The primary factor affecting the data gathered throughout the testing sessions were the short duration of time and the small number of participants (eleven in total). The logistics of the testing session had to be improvised accordingly to suit the time slot allocated to test within provided by the school. The children on average spent less than 5 minutes playing, meaning the full extent of the behaviour of the prototypes could not be exhibited during this extremely short timespan.

Furthermore, this data does not accurately represent or predict the behaviours exhibited if the game was played over a day in the various contexts and with people that the child interacts with daily.

It is also worth noting that the context allocated for this session was an outdoor terrain of the schoolyard, that differed significantly to the previous indoor locations assigned for testing during the ideate phase of the project. Even though this area is representative of a typical playing environment for a child, the area lacked in props to interact with that could have potentially influenced them to take different strategies throughout the testing sessions.

The context naturally influences more chasing activities amongst the children. Undoubtedly, the terrain of the schoolyard influenced their behaviour and provoked the majority of the children not to bring play down to the ground in fear that they might hurt and subsequently spotted in doing so by the supervisors present in the schoolyard at that time. Furthermore, the children were hyperactive with the prospect of missing class for a short period of time, and this could have also influenced the behaviour exhibited throughout the testing sessions.

At times throughout the session, children from other grades were present in the schoolyard during their recess, where many observed what the participants were doing. Some would briefly enter the designated play area and leave again as requested by their supervisor. This was distracting to the participants in some instances.

As the testing session endured, the prototypes gradually began to get less robust due to play. The continuous removal and application of the shirt on the children caused components and wires to get loose and making the prototypes behave glitchy in terms of the prototype behaviour. This required an impromptu approach, with the facilitator intervening as a referee and estimating the participant's heart rate based on their activity levels. When a specific child heart rate was high or low, this was immediately informed to the children and vice versa.

The prototype behaviour was far from perfect and needs further optimisation to suit. The visual feedback from the neopixels placed above the upper locations was not apparent to the children at times. The neopixels were quite small and were hard to identify in the brightness of the outdoor conditions.

5.4.5 Conclusions

With the results in mind several conclusions could be made about the concept and its rebellious potential.

The outcomes of the heartbeat strategies were thoroughly disappointing as this feature was identified as a significant aspect of the original concept during the 2nd testing round of the ideate phase (as outlined in 3.8.5)The children placed less emphasis on this aspect of the game compared to the tagging element of the game as they just wanted to be constantly active throughout their respective sessions.The majority of the children primarily rejected lowering their heartbeat as a defending strategy. Some saw this as a burden to the overall play experience as they wished to tag each other continuously. As explained in 3.8.5 the heartbeat element as a separate entity, it showed a lot of promise. However combining both heartbeat and tagging strategies and expecting a clear outcome with the limited time per session and location was extremely ambitious. This may have reduced the number of dilemmas to arise for the children to encounter within this short time span. This could have been due to the threshold being set too high (100 bpm) and perhaps should have been lowered to capture the entire dynamic of the game in the given time.

Similar to the heartbeat strategies, the children had a more proactive approach to tagging each other as evident by the constant chasing activities exhibited by the majority of the children. The aesthetics of the prototypes were liked by children and immediately associated it with superheros, space and robots. Some of the children gave the impression by wearing the garment that they got superpowers and this could have influenced their energetic behaviour they shown throughout the testing sessions.

Bouts of rebelliousness occurred throughout the session and challenged boundaries on several hierarchical levels. The general trend developed with their strategies was if it is not acceptable within their contextual surroundings, it is highly likely that it is acceptable in society as instilled by the staff of the school. Based on the framework, contextual and societal rules were the most violated during the testing session. What became apparent was that societal and contextual rules may not be distinct categories but merged within the rule hierarchy framework established in 5.3.

The majority of the children were open and admitted that they partook in acts of rebelliousness in their respective sessions immediately after, while debriefing. Some were too shy to admit and appear innocent, but their guiltiness was made apparent by their lack of communication, facial expressions and sniggering laughs. They understood that some things they did were naughty, but they could not precisely define why. Many of the children defined the boundary of rebelliousness to physically hurting each other and realised the consequences that could arrive with, referring to forms of injuries requiring medical attention. Rebelliousness was present, however it cannot be defined whether these behaviours were directly due to the prototype, the context or the motivational state the children were in prior to completing the test.

Furthermore some of the children tried to justify the motivations for their actions during play. Some used it as a display of dominance and power over their peers, that reflects the literature discussed in 2.5.2.Others claimed they did what they did to just protect themselves from being tagged. Some expressed their behaviour as retaliation to actions inflicted on them by their opponents during play.

Some of the children established reasoning for the behaviour they expressed through their strategies. The strength of the participant's relationship appears to play a crucial role in what they do to each other. Some children stated a desire to inflict harm on each other but ultimately would not carry through with the action due to the strength of their friendship. If the relationship is more distant or non-existent between the children, the children suggested that they were willing to cross the boundary by hurting them. This issue could be brought to light and clarified if there is a larger sample obtained for testing, where some of the children would be less familiar with each other.

6. Recommendations

6.1 Prototype/Design Recommendations:

Feedback:

- The visual feedback from the neopixels placed above the upper locations was not clear to the children at times. The neopixels were quite small and were hard to identify due to the brightness of the outdoor conditions. Furthermore, all the tagging areas should have a corresponding visual feedback medium as the children initially thought that the three pixels on the upper part of the garment represented a life. Larger visual cues for each tagging area on the shirt are required to overcome this shortcoming.

- Electro-luminance (EL) could be a suitable alternative to the neopixels and would resemble the desired vision of the X-eo concept. EL is available in film and screen print format and could potentially accommodate this function as it can be shaped into desired patterns and shapes. (Verhoechx, 2018).

- Individual visual feedback per player should be integrated subtly, preferably within the visual periphery of the child as to eradicate the need to glance down at their chest or upper arms to assess their life status during play. Furthermore, haptics applying haptic feedback within the design could also clarify this issue and should be further investigated.

Tagging areas:

- With regards to the tagging areas in the game, the areas on the upper half of the torso were preferred targets by the children. The orientation of the tagging areas on the upper arms should be rotated by 90 degrees to follow the anatomy of the area to make protecting areas more intuitive. In hindsight, the tagging areas should be of equal size, as to not have the children targeting one specific area throughout gameplay.

- Surprisingly the laterals were not utilised much even though they visually appeared to be the largest tagging areas. Further testing would be required to see if the areas are worthy of staying in the design or an alternative area should be sought.

- In hindsight replacing the capacitive touch should be replaced with pressure sensors to reduce the glitchiness of the prototype and reflect more of the components to be integrated into the desired version of the designed concept. The sensors could be directly placed under the EL patterns to accommodate the tagging element of the prototype.

Manufacturing:

Concerns were raised about the presence and exposure of wires and other components on the shirts as the children were afraid that they might hurt them. The following aspects should be addressed to tackle this issue:

- Components such as the microcontroller boards soldered wires and resistors should be embodied with a casing to contain excess wires neatly, to make the shirt more comfortable for the children to wear while playing.

- The conductive thread proved to be a troublesome element of the prototype due to its resistance and its glitchy behaviour at times. An alternative option more suitable for active wearables should be investigated.

- The heartbeat sensor should be fixed to the wrist/forearm area as opposed to the index finger, as to allow the child both hands to tag and protect themselves with during play. The potential added benefit in doing so is reducing the need to insert cables in the shirt to reach down through a sleeve to the index finger, which was awkward and cumbersome to the child while wearing the shirt.

6.2 Testing Recommendations:

Logistics:

- The hardest part of the testing sessions throughout the entire project was not facilitating them, but arranging the logistics of them with the teaching staff and the school management.

- The author was limited to the schools in the area due to his limited understanding of the Dutch language. Therefore an international school with English as the spoken language was required. If the opportunity arises to collaborate with a former school, it should be taken as there is a previous relationship between the parties established and therefore they might be more willing to work together.

- A teaching schedule should be requested so the testing sessions can be thought out more thoroughly with regards to the times and locations available. Furthermore, consent forms should be distributed to the participants as soon as possible so an estimated number of participants can be established, so more definite testing set-ups can be arranged.

- Moreover, a secure means of communications with the school stakeholders should be obtained to make organising and confirming the sessions more concise and convenient.

Facilitating:

- Managing the testing sessions by oneself was extremely challenging, between, setting up the test location, observing and ensuring that the session runs smoothly. It is advised to bring an assistant to the session to help with the set-up and primarily take notes during observation to make analysing the video data more concise later in the process.

- The sessions throughout the project were extremely short in duration. If the sessions could be extended in duration, it might allow the participants to interact and play with the prototypes long enough to uncover their full functionality.

- It is important that the children understand that the facilitator not an authoritive figure. Facilitators should explain that are students just like themselves. This needs to be clarified as soon as testing commences with the children to let the children feel free to do what they want throughout the testing sessions.

Prototype- heart rate element settings:

- In the event of testing sessions remaining short in duration, the heart rate threshold should be lowered from the 100BPM to a lower value. In doing so it might create more clarity with regards to the strategies the children implement for raising their opponent's heart rate and lowering their heart rate.

7. Reflections:

Reflection and evaluation of the research methodology applied

Research of this nature is extremely challenging to conduct. I found this especially to be the case as I was investigating a phenomenon that has very little written or known information about it.

I found it useful to establish some sort form of structure to conduct the research, as there was a vast amount of aspects and psychological content to investigate. Creating the definition of rebellious play at the start of the project was vital, as it was created to grasp the phenomena to be researched throughout the project. It ensured that the phenomena were clearly understood and that there was something to refer back to while identifying instances of rebellious play behaviour later in the project. The definition is relevant in the domain of rebellious play and if accompanied by the previously outlined literature, it sets a solid foundation to begin researching rebellious play.

If future research candidates feel it is not applicable, they likewise should set-up their own definition of rebellious play that they feel comfortable with and best represents the literature gathered.

A qualitative approach was definitely the way to tackle this research. As discussed with other researchers within the faculty and Lieselotte van Leeuwen, a quantitative approach would have been misunderstood as we wanted to identify as opposed to measure rebellious behaviour.

Having a debrief conversation with the children after the testing sessions worked well. It was a good way to try and triangulate some of the immediate instances observed. It's worth keeping in mind that some of the answers provided of the children may not be 100 per cent reliable as they were influenced by many things happening within their context and may not have fully understood what was being asked. Furthermore, triangulation could be strengthened by showing the children the interesting pieces of data from analysis and having them reflect on what they did during the testing session.

Creating the hierarchical framework of rules and the rebellious play grid sheet was the breakthrough for identifying rebellious behaviour. For previous tests throughout the project, this was primarily based on my assumptions and intuition, but I could not precisely recognise if what the children did was rebellious or not. By having the framework, I was able to establish and operationalise on which level their behaviour was rebellious based on meta-observations. I highly recommend using this framework or something similar as a tool while researching rebellious play, as a means to identify, classify and come to conclusions on whether the play behaviour observed was rebellious or not.

In hindsight, looking at the whole process, The requirements for rebellious play model outlined in 2.5 should not be strictly followed as a research model. It was originally created as a tool to define to investigate aspects that could influence rebellious play. In the end, it evolved into a design model and therefore is not directly linked to the hierarchy of rules framework previously described.

Overall I think the methodology of the research applied was logical. It was not perfect by any means. But with the recommendations and suggestions made, I hope it provides a solid foundation for further work and research to be conducted on rebellious play behaviour.

Reflection on the design process

The design process I undertook through the iterative design loop implemented was logical to accommodate the research. It allowed for constant building on information previously obtained.

I felt that the design elements of the project felt a bit rushed, especially during the transition from the understand phase to the ideate phase, and likewise for the transition between the ideate and make phases. This was mainly due to dealing with an overload of information. Breaking the research into smaller manageable parts worked really well for ideation.

I usually implement a looser, open approach while designing, but having a more structured and methodical driven process allowed me to make more reassured choices, even if I did over-think them at times.

I continuously found myself reminding myself that I was conducting a research project and not a thorough product development project. This was due to design and research activities running parallel to each other. I did find myself fixated and "down the rabbit hole" at points, especially during the make phase while differentiating between the aspects of both the concept and the prototypes. Thankfully my mentors guided me out of it, if I was getting too deep into a specific issue and I was able to realign myself.

Considering where I began, I was pleased with the final outcomes as I initially thought I would not even get to the feasibility level I did with the prototypes.

Reflection on design brief

With regards to the project assignment brief, I think I managed to address it.

While still holding the same principles, the bangerik concept was re-thought and evolved into the form of X-eo. It functions remained similar but is embodied in a garment with more focus on the feedback it provided players throughout gameplay.

Test worthy "minimal viable prototypes" were created for the context and provided an abundance of insights on the phenomena. The robustness of the prototypes can be questioned, but they did meet the conditions of investigating the occurrence of rebellious play behaviour.

Personal Reflection

To be honest, I did not know what I was signing myself up for with this project before starting it. I never partook in such a research-heavy assignment through out my time at IDE. The project was one massive learning curve for me both academically and personally. I hope that my experience reflects in this thesis and will provide future graduation students with a better idea of what to expect if they decide to continue this work or researching rebellious play behaviour.

With regards to the learning goals proposed at the start of the project, looking back I feel I have managed to reach the majority of them.

I managed to get my hands dirty and get into interactive prototypes. It was the most enjoyable, frustrating and favourite aspect of the project. This kind of prototyping was relevantly alien to me as I was primarily used to making analogue and aesthetical prototypes. I'm still not entirely comfortable with programming as such, but I learned so much about electronics, components, software and how to replicate product behaviours. My patience was tested at times with this, but nothing could beat that feeling of when your prototype finally worked.

I went through an iterative process during the iterative design loops implemented in the ideate phase of the project. I was surprised by how much information I gained from every prototype I built, regardless of how minimal or complicated it was. The process felt logical as I continuously built from the foundations established during the understand phase all the way through the ideate phase. I found this to be a valuable approach to design and research alike, and will definitely be implementing it again.

My knowledge of designing and researching for play has been broadened and I found it rewarding. Furthermore I managed to use and transfer knowledge gained from the project into applying for various positions with sporting companies and had fruitful conversations with them. I am sure the theory and insights gained will be of benefit to me if I continue to pursue this route.

I wanted to improve my visual communication skills and I wished I had more time to do this within this thesis document. It is still an "Achilles heel" of mine and I'm still not entirely happy about it yet, but I definitely utilised the medium more often than my previous reports I have submitted throughout my time here. Nonetheless, it has given me some confidence and a foundation to keep trying to improve these skills and apply them in future projects I may have.

Lastly, I wanted to learn to be comfortable in managing a project by myself. Planning is a weakness of mine, however, I felt it has improved and I gradually got more comfortable with it throughout the project. In hindsight, the key to managing a project is about embracing "expecting the unexpected". Things undoubtedly went wrong and didn't work out at times, but adaptability was vital to overcoming these issues. This was especially the case with organising logistics with the school, facilitating the testing sessions and prototyping. I learned to trust myself more with this aspect and that I am more than capable of doing so.

Before I bring this thesis to a close, I would like to share some advice to future students based on my experiences during graduation:

-Be kind to yourself, and try not to beat yourself up. You are a "one-man band" after all and you're doing the whole project by yourself.

-Take breaks. Being tuned into a project continually is not good for your creativity and productivity. Don't be afraid to put it aside for some time, and do other things. You will definitely gain some inspiration and it will give you different perspectives and energy on how to approach things.

-It's okay to get lost. It is a part of the journey of graduation.

- Trust the process. You will feel lost and frustrated at times but just follow through with it and you will get out the other side of it somehow and it will all work out.

-If your intuition /gut feeling feels right, go with it and find out why it is pointing you towards a specific direction.

-Actions speak louder than words.

-Don't overthink things. Just do it!!

- The enjoyment of the project comes from actually doing it, and not just focussing on the end result.

-Breathe! If something doesn't work out it's no the end of the world.

-And finally in the words of U2 "sometimes you can't make it on your own". Don't be afraid to raise your hand and reach out if you need help. Friends and people around the faculty are more than willing to help you.

References

Literature

Apter, M. J., & Smith, K. C. P. (1976). Negativism in adolescence. The Counsellor, 23(24), 25-30.

Apter, M. J. (1982). The experience of motivation: The theory of psychological reversals. Academic Pr.

Apter, M. J. (2007). Reversal theory: The dynamics of motivation, emotion, and personality. Oxford: Oneworld.

Bateson, G. (1972). A theory of play and fantasy: Steps to an ecology of mind. New York: Ballantine, 177-193.

Rosales, A., Sayago, S., & Blat, J. (2015). Beeping socks and chirping arm bands: wearables that foster free play. Computer, 48(6), 41-48.

Eberle, S. G. (2014). The elements of play: Toward a philosophy and a definition of play. American Journal of Play, 6(2), 214-233.

De Valk, L., Bekker, T., & Eggen, B. (2013, June). Leaving room for improvisation: towards a design approach for open-ended play. In Proceedings of the 12th international conference on interaction design and children (pp. 92-101). ACM.

Gielen, M. A., & Van Leeuwen, L. (2013, August). Rebel by design: The merits of rebellious play and how to design for it. In IASDR 2013: Proceedings of the 5th International Congress of International Association of Societies of Design Research, Tokyo, Japan, 26–30 August 2013.

Van Leeuwen, L., & Gielen, M. (2018). Design for Rebellious Play. In Toys and Communication (pp. 255-274). Palgrave Macmillan, London.

Luijpers, B. J. M. (2014). Rebels at play: Exploring co-research to design a rebellious playground. TU Delft: unpublished master thesis.

Mathye, L. V . (2004) Therapeutic techniques for treatment of adolescents with rebellious behaviour. University of South Africa, Pretoria: unpublished doctoral dissertation.

McDermott, M. R. (1988). Measuring rebelliousness: the development of the Negativism Dominance Scale. In Advances in Psychology (Vol. 51, pp. 297-312). North-Holland.

Tietze, T. (2019), Design of a cyborg NERF blaster for children with physical disabilities.: Using the abilities of children with physical disabilities, as inspiration, to create a toy that introduces new, desirable play features onto the regular toy market and thus supports inclusion . TU Delft: unpublished master thesis.

Bijl, W.M. van der (2000). Bio play-along. Een ontwerpvisie op 'buiten spelen'. (Bio-play-along. A design vision on 'outdoor play'; in Dutch). TU Delft: Unpublished master thesis.

Verhoeckx, J. (2018) , ELECTROLUMINESCENCE; a user-orientated material driven design. TU Delft: unpublished master thesis.

Sandford & Mill, (2006), Resistance through video games.

Sanford, K., & Madill, L. (2006). Resistance through video game play: It's a boy thing. Canadian Journal of Education/Revue canadienne de l'éducation, 287-306.

Sutton-Smith, B, (1997). The ambiguity of play, Harvard University Press, Cambridge.

Images

Figure 2.6

Central image: https://www.kiwifamilies.co.nz/articles/5-to-10-year-old-child-behaviour/

Figure 2.6

No consequences: https://myglimpsesofglory.wordpress.com/tag/child-of-god/

Free of supervision: https://www.thejournal.ie/what-is-it-like-being-a-child-in-ireland-today-823954-Mar2013/

Frustration: https://myplinkit.com/2017/09/16/self-regulation-part-ii-body-engine-checker-system/

Continuous dilemmas 1: https://heartmindonline.org/resources/5-step-problem-solving-for-young-children

Continuous dilemmas 2: https://www.thespec.com/living-story/7392648-motherlode-teach-your-kid-to-stop-screaming/

Figure 2.8
Rule book: https://pmojournal.com/wp-content/uploads/sites/21/2018/07/Rulebook-to-Infallible-Project-Plan-780X405.jpg

Kids fighting: https://i.ytimg.com/vi/UGd838PgEMc/maxresdefault.jpg

Forced: https://www.cjnews.com/perspectives/opinions/kwinter-shaping-our-own-traditional-religious-and-cultural-practices-within-the-modern-world

Figure 2.13

Fortnite: https://www.epicgames.com/fortnite/en-US/patch-notes/v8-00

GTA: http://ireadfaux.com/2014/11/gta-v-reboot-gets-first-person-mode/

The Sims: https://www.origin.com/nld/en-us/store/the-sims/the-sims-4

Pie face: https://www.thetoyshop.com/games-jigsaws/family-games/Pie-Face-Showdown-Game/p/527898

Fart fun: https://www.amazon.com/Despicable-Me-Fart-Blaster-Trigger/dp/B01614KGCK

Don't Step in it: https://www.youtube.com/watch?v=UjztIsqVI2Q

Nerf gun: https://www.newshub.co.nz/home/world/2018/09/uk-police-called-to-investigate-nerf-battle.html

Figure 2.14

Apple watch: https://myimaginestore.com/category/watches/apple-watch-nike/apple-watch-nike-42mm-space-grey-aluminium-case-with-black-volt-nike-sport-band

Bose wireless earphones: https://www.amazon.com/Bose-SoundSport-Truly-Wireless-Headphones/dp/B0748JM8M5

Digit sole: https://www.amazon.ca/Digitsole-Connected-Insoles-outdoor-hunting/dp/B01N01ZPHS

Polar heart rate sensor :https://www.pcmag.com/review/355524/polar-h10-heart-rate-sensor

Smart sleeve: http://komodotec.com/product/aio-sleeve-sale/

Finger mouse: https://www.wearable-technologies.com/2015/09/wireless-wearable-mouse/

Green Fitbit: https://www.institutionalinvestor.com/article/b14z9v2bqycp61/profiting-from-the-boom-in-wearable-technology

Construction wearable: https://www.digitaltrends.com/mobile/interesting-wearables-at-mobile-world-congress-2018/

Figure 2.15

Bluetooth vest: http://static2.cdn.ubi.com/ncsa/battletag/website/reveal/img/bt-vest.jpg

Super suit: https://steemitimages.com/

Pokemon go wristband: https://www.amazon.com/Nintendo-Pokemon-Go-Plus-Android-iOS/dp/B01H482N6E

Simon says glasses: https://cdn.vox-cdn.com/thumbor/

Kids tracker: http://www.mygunnedah.com.au/the-best-kids-trackers-using-wearables-for-child-safety/

Filip 2:http://www.mygunnedah.com.au/the-best-kids-trackers-using-wearables-for-child-safety/

Figure 2.16

Pulse sensor: https://www.kiwi-electronics.nl/pulse-sensor?lang=en

Pulse/tissue oximetry: https://www.medgadget.com/2010/12/inspectra_sto2_spot_check_tissue_perfusion_monitor_gets_european_clearance.html

ECG: https://www.wareable.com/fitness-trackers/aio-smart-sleeve-specs-price-release-date-2547

Photoplethysmography:

https://medium.com/@lloydgprice/physics-and-light-apples-competitive-advantage-in-healthcare-2dcba07ba22

Figure 2.17

Stainless steel conductive thread: https://www.kiwi-electronics.nl/stainless-thin-conductive-thread-3-ply-18-meter?search=steel%20thread&description=true

Conductive ink: https://www.oldcitystationpub.com/choosing-the-right-conductive-ink-for-your-printed-electronics/

Woven conductive fabric: https://www.kiwi-electronics.nl/woven-conductive-fabric-silver-20cm-square?search=Woven%20&description=true

Pressure sensitive conductive sheet:

https://www.kiwi-electronics.nl/pressure-sensitive-conductive-sheet-velostat-linqstat?search=pressure%20sensiti&description=true

Figure 2.18

Pulse sensor: https://www.kiwi-electronics.nl/pulse-sensor?lang=en

Xbee:https://www.sossolutions.nl/128-xbee-module-series-1-1mw-with-wire-antenna?gclid=CjwKCAjwk7rmBRAaEiwAhDGhxD9IA06Y1PDitv5UpONO41hf0tG27NOMASbNQJdZMKKlz9FM8ahu4RoCxFAQAvD_BwE

Figure 4.7

Ben 10: https://ben10.fandom.com/wiki/Ben_Tennyson_(Reboot)/Gallery

Powerpuff girls: https://www.atlantamagazine.com/90s/the-powerpuff-girls-epitomized-90s-girl-power/

Teenage mutant ninja turtles: https://hero.fandom.com/wiki/Leonardo_(TMNT_2018)

Kim Possible: http://los40.com.mx/los40/2018/04/27/cinetv/1524783788_521175.html

Star wars Resistance: https://www.superpoweredfancast.com/new-episode-of-star-wars-resistance-coming-this-sunday/

Big Hero 6: https://bestspecialnews.com/tv/disney-channel-renews-big-hero-6-the-series-for-third-season/

Miraculo: https://tv.disney.co.za/

Teen Titan go: https://www.amctheatres.com/movies/teen-titans-go-to-the-movies-54413

Transformers: https://www.allspark.com/tag/cyberverse/page/3/