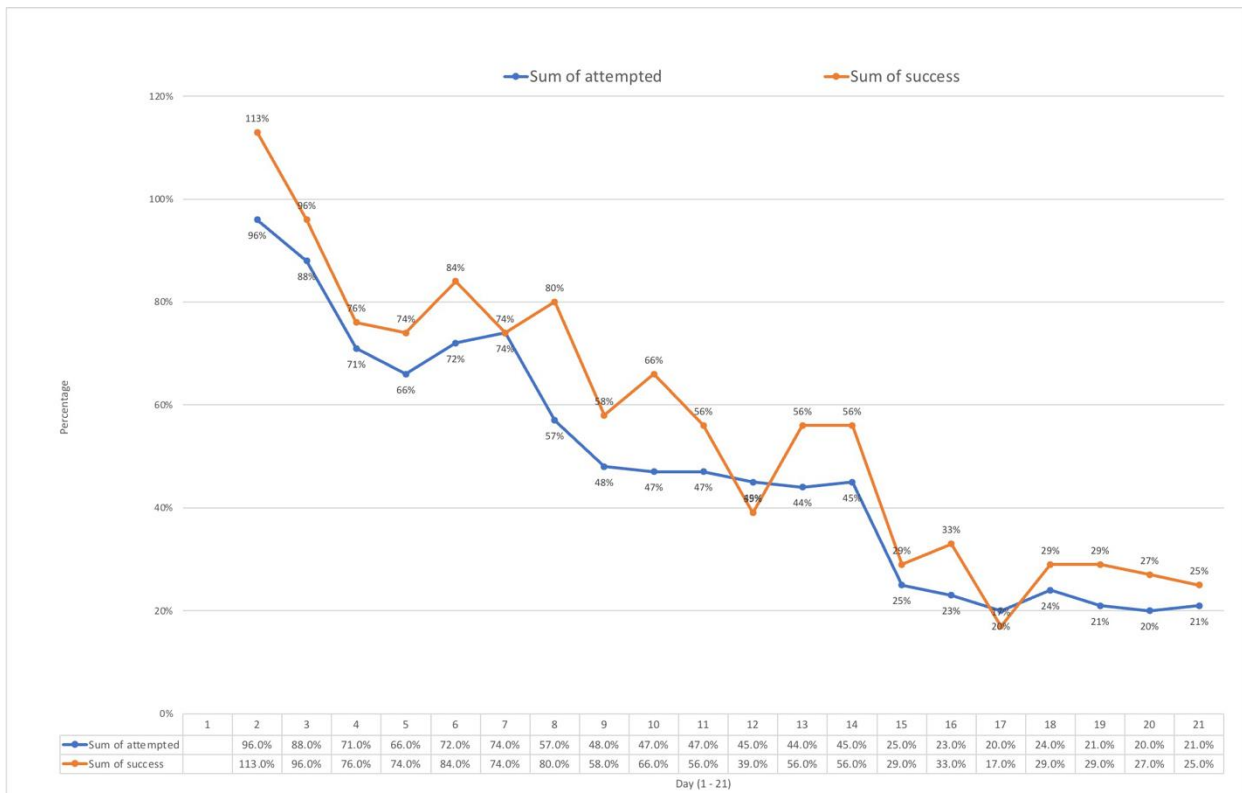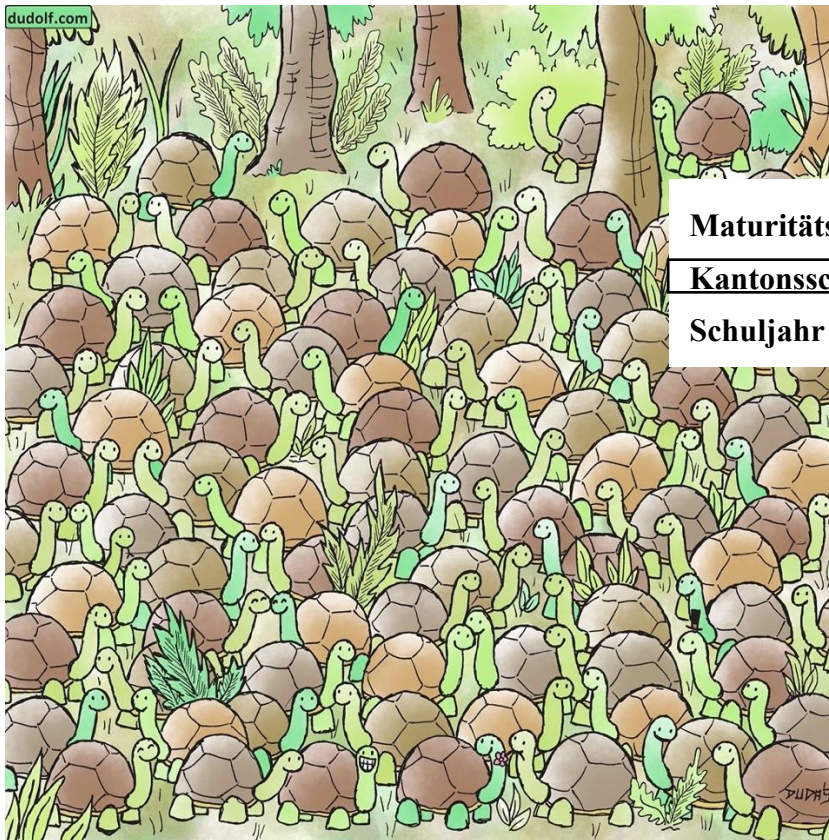# Analysis of the Formation of Habits

Description: we can see the progression of the daily attempts and the success by all participants over the course of three weeks.

Can you find a snake among the tortoises?

Maturitätsarbeit von Michelle Beasley 6b

Kantonsschule Hohe Promenade Zürich

Schuljahr 2023/2024

Betreuende Lehrperson:

Manuela Fuchs

Korreferentin:

Martina Nüesch

Declaration

I, Michelle Beasley, hereby declare that I have written this thesis «Analysis of the Formation of Habits» independently and without the use of other sources or aids than those indicated.

Place, date: _____   Signature: _____

Abstract

In order to understand how habit formation works and to determine which factors affected this the most, a study was conducted with 132 volunteers[1]. The participants were asked to attempt a visual puzzle on a daily basis over the course of three weeks. To allow for comparative analysis, the volunteers were divided into five groups, four intervention groups and a control group to function as a reference. The four intervention groups were: extra motivation, two habit stacking groups and one task bracketing group. The only difference between the extra motivation and the control group was that the extra motivation group had additional positive words of affirmation for the completed tasks. One of the two habit stacking groups was asked to stack onto a weak and the other group was asked to stack onto a strong pre-existing habit. The last group was to apply task bracketing as an implementation strategy. The ages of all the participants varied between 15 and 86 years old with both male and female volunteers. The study was performed anonymously, meaning none of the volunteers were aware of the nature of the study. The data was collected with the help of an online survey (Survey Monkey) on a weekly basis. The pursuit of my objective, even though there are multiple studies that could follow this study, was successful in achieving my goals, which were to investigate and confront my hypotheses extensively, through a study of habit behaviour and formation.

A third of the volunteers (44) only signed up, however did not execute any of the tasks. Of the remaining 88 participants that started the study on day one, only 18 of them attempted the task on the final day. The extra motivation and the weak habit stacking group had round a third of the participants of the first day still engaged on the last day. Better performance (completion rate) was more apparent in the older age categories, with participants older than 59 years old having the best performance with a flat progression ending at 40 percent. Whereas participants younger than 20 years only achieved 14 percent. There are only very slight differences noticeable in gender. The impact a sick day had was far larger than the impact of a busy day. The general trend of the study was a decline towards 21 percent however the biggest declines could be seen after each week. Some of these tendencies were not predicted correctly but as we shall see they could have been anticipated.

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[1] In my paper I systematically differentiate between volunteers and participants. Volunteers describes the sum of people who applied to be in the study whereas a participant is defined as someone who attempted the task at least once in the study and thereby produced fact supported data. All volunteers who do not count as participants only deliver indirect data, we can deduce information from.

Acknowledgements

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1 Introduction:

To take a closer look at how habits are formed and sustained, I conducted a behavioral study. I worked with a sample of 132 individuals that were all given the same simple task to repeat, with the intention of them creating a new habit. I instructed all volunteers with the same general conditions and individually gave them guidance on the approach they would be taking. The aim of my study remained concealed for the duration of the study, leaving volunteers in the unknown to minimize disruptive factors. The objective of my paper was to establish an understanding of how habit formation works and which parameters[2] influence the process and outcome the most.

1.1 Habit

A habit is not just a frequent, non-consciously performed behaviour that reoccurs under the same circumstances. Efficiency, speed and saving cognitive resources are a few characteristics that belong to a habit. It is a reliable solution to turn to when the same issue reoccurs. (cf Orbell,4.7.20, Changing Behaviour Using Habit Theory)

1.1.1 Habit cycle

The habit cycle is identical no matter the habit. This cycle also referred to as the habit loop consists of four stages which follow a particular order. The first component of the loop is the cue. A cue is a piece of information associated with a particular habit noticed by our sensory nerves. Most cues are visual cues as around ten million receptors out of the eleven million receptors humans have, create the picture of what we see. The cue triggers a craving (second stage), if acted on, the response (third stage) is the habitual behaviour our brain can perform on autopilot. To complete the loop and acting as reinforcement, follows the immediate reward (fourth stage). If our expectations are met and the reward made us feel good, we feel satisfied. However, if this is not the case, we feel disappointed. We are inclined to repeat the action, which lead to the satisfaction of a craving, the next time the same cue is recognised in order for us to reap the same benefits. (cf Clear, 2019, Atomic Habits, p45-51, p81-93), (cf Hreha, after 2017, Habits are reliable solutions)

1.1.2 Part of our identity

Habits are a self-reinforcing process, the anticipation of the reward makes us take action, the reward is what sustains the habit. With greater reward the likelihood of repetition increases. Up to 70 percent of our daily practiced actions are habitual. The more profoundly ingrained into our lifestyle, the more these behaviours are entwined around our identity, which acts as a positive feedback loop. As we perform a habit, the behaviour becomes attached to our identity and we act in alignment to our identity because that is essentially who we are. Habits are heavily dependent on environment and our state of well-being. With increased repetitions the automaticity and probability of a certain habit grows. (cf Clear, 2019, Atomic Habits p29-41)

1.1.3 Perceived stress

We all experience stress; anchored habits can try and counteract stress as their non-conscious execution frees up the mental load that can be allocated to other tasks. This is of high value as the brain is only capable to efficiently tackle one problem at a time. However, modern day stress does raise the difficulty of incorporating a new habit into our day-to-day life, often we are simply too stressed to be able to accommodate a new habit.

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[2] In the framework of this paper, I will refer to the examined variables in habit formation as parameters to maintain a clear structure.

The term perceived stress detangles the complexity of all the variables linked to stress and its impact on an individual. This measurement makes the stress individuals feel more comparable, not by eliminating the subjectivity, but by clarifying the fact that its measurement is indeed highly subjective. This entails that the same event can be varyingly stressful for any two individuals. Their response to stress is equally variable depending on how they manage stress. Stress management is an ability that can limit the impact perceived stress has on our well-being. Sometimes it is not the cause of stress that needs to be addressed but the cognitive process of stress evaluation and management. Perceived stress impacts subjective well-being, just as stress can be perceived differently so can well-being. Individuals that have better time management can potentially cope with higher stress levels. However, I should mention that stress does also have beneficial effects on individuals as it can increase our concentration levels and can thus make us function with greater efficiency. (cf Health Assured, 2019, The difference between stress and perceived stress), (cf Reddy, 2023, Perceived Wellbeing, Happiness, and Related Challenges among Indian Students)

1.1.4 Successful habit formation

When do we succeed to form a habit and when do we fail? Habit execution is dependent on our state rather than our schedule. There are multiple variables that determine whether a habit can be formed or not. In addition to each person being a variable, it depends on their reason for a new habit, their attitude and their personality, strengths and weaknesses in the field of the particular habit. Furthermore, the approach taken, the environment, the habit strength (see 1.2.4) strongly influence the outcome. Additionally, life has unexpected obstacles that get in the way, which can cause stress, creating another variable.

We can confirm an action has become a habit once a cue can be consistently responded to with an automatic execution of the habit. The mainstream media makes 21 days out to be the magic number, but a study conducted by Sarah Milne in 2010 found it can vary anywhere between 18 and 254 days. In this study volunteers were asked to either carry out the same eating, drinking or activity behaviour daily in the same context. Out of 96 volunteers 82 participants provided sufficient data to analyse. After each day they filled out a self-report habit index, similar to my survey just at a higher frequency. To date there is no conclusive number of days as to when a habit can be confirmed as established. (by Milne, 2010, https://onlinelibrary.wiley.com/doi/abs/10.1002/ejsp.67), (cf Clear, 2019, Atomic Habits 22-25)

1.2 Why exactly do we repeat a behaviour? – A neuroscientific background

1.2.1 Memory

To fully comprehend the habit loop, it is necessary to look into the neuroscientific aspect of habit formation. A habit frequently consists of a sequence of multiple processes. In order to repeat a habit, the sequence of processes has to be intuitive - this is where the procedural memory plays an important role. Procedural memory is a type of implicit[3] long-term memory. This non-consciously formed memory can be viewed as an instruction of a specific sequence of events that need to occur in order for an action to be completed. It is not just the actual repetition of an action that strengthens the automaticity, but also visualisations of the particular action. Each visualisation would have to go through the sequence of steps of the process. Visualisation is not a trick on the nervous system but if done properly, some of the neurones needed would fire as if the habit were performed. (cf. McDowell, 2010, Measures of self-perceived well-being)

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[3] In this context implicit refers to the memory formation, which cannot be remembered, the memory is there but when this particular knowledge was learnt is unclear.

The second branch of long-term memory is the explicit[4] long-term memory. These memories have to be recalled actively. There are two subdivisions to this branch: the episodic memory, which remembers certain events and the somatic memory, which has the ability to remember concrete facts. Some habits additionally require parts of the explicit memory but during the formation of a habit, the procedural memory has a far higher relevance. (cf Clear, 2019, Atomic Habits p144-147), (cf Cherry, 2023, Procedural Memory), (cf Ohwovoriole, 14.3.23, Different Types of Memory)

Image 1
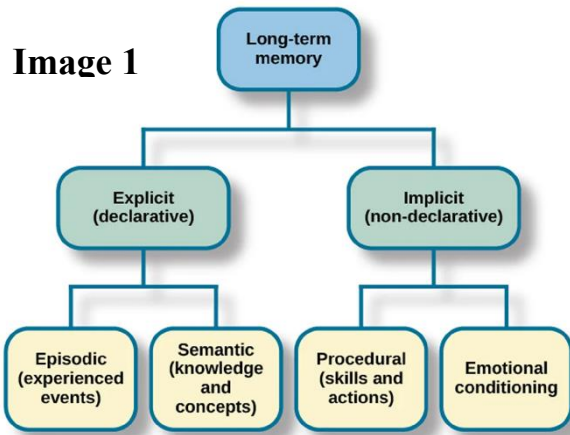
Description: a scematic overview of the long-term memory.

1.2.2 Dopamine

As each habit loop that is repeated is identical, each response is preceded by a craving and followed by a reward. The craving for the reward is not the actual initiator and neither is the visible reward the actual reinforcement, but it is the processes that happen on a microscopic scale which are what initiate, drive and sustain a habit. Dopamine is the main neurotransmitter involved in both habit formation and performance. It is the molecule of desire and directs us towards certain habits. Dopamine both effects motivation and focus positively. After a dopamine release, we typically feel driven towards something or fulfilled with pleasure.

A spike of dopamine is released as we anticipate a reward but as soon as the habit is embedded into our lifestyle there will not be a second spike when the reward is received. The only time there is a release of dopamine once the reward has been received, is when it is the first time performing a certain behaviour or when the reward is delayed. In this case the lack of the dopamine levels formed by disappointment, are overshadowed by the reward to ensure that the action will be repeated again. This gives the scientific explanation as to why anticipating a reward can actually feel better than attaining it. The distinct difference between wanting[5] and liking is that wanting is a crucial movement activating force pushing us towards rewards and liking is enjoying the reward. Anatomically there are bigger and denser regions of the brain focused on wanting in comparison to liking.

As dopamine forms a central part of habit formation and even of habit sustaining, we need to look a little deeper into the topic of the subjectiveness of dopamine. The reward received immediately after the completion of a habit triggers a release of dopamine. The effect that dopamine has on our body is linked to the associated reward of the specific cue. Such that the brain only recognises the associated rewards to specific events. The perception of a reward makes the release of dopamine subjective. Taking this factor into account on top of the variability of human beings, helps to explain the variability of habit in different people.

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[4] Explicit means the memory was actively formed and we are able to recollect the circumstances of the memory.

[5] Wanting is solely used in the linked sense to cues and cravings.

(cf Clear, 2019, Atomic Habits p105-108), (cf Huberman, 2022, Tools to Manage Dopamine and Improve Motivation & Drive), (cf, Pietrangelo, 2019, How Does Dopamine Affect the Body?), (cf Bhandari, 19.7.23, What is Dopamine)

1.2.3 Neuroplasticity

The brain physically changes in response to which activities we indulge in. This capability of shifting the efficiency of certain neural connections, based on what field of experience they have been collected in, is called neuroplasticity. Neuroplasticity is composed of two main processes: Neural growth and neural pruning. A cell assembly[6], which is fired repeatedly, will lead to new neural pathways[7] and growth in synaptic knobs, in order to enhance efficiency and performance. This process is called Hebbian learning, which in Hebb's theory can be summarised as "The neurones that fire together wire together". A neural pathway is pruned or reduced in synaptic strength if it is rarely activated. Hence the more a path is followed the stronger it becomes, with less used paths eventually fading away. Activation of a neural pathway happens by transmission of an electric impulse. Neuroplasticity is of high value due to its ability to adapt the efficiency of transmission of certain pathways and save materials and energy on pathways that are rarely fired. A path that is frequently fired requires reduced input to be activated. As we get older, the process of neuroplasticity declines and the ability of the brain to evolve its neural networks and adapt becomes restricted. (cf Clear, 2019, Atomic Habits, p143)

1.2.4 Habit strength

There is a further aspect that has to be taken into consideration, not every habit is embedded into our identity to the same extent. We set our priorities according to how closely we view them connected to our persona. We go through a value assessment and range our habits from non-negotiable to fully flexible. The so-called habit strength correlates to two factors: context dependency and limbic friction.

Context dependency, refers to how reliant a behaviour is to the current circumstances an individual is in. Circumstantial influences such as the weather, physical and mental health, stress level, "working situation" (to be on holiday or at work) all have an impact on human behaviour. The lower the dependency on any factor the stronger the habit.

The niche term limbic friction refers to the effort, that needs to be overcome to do certain task. As the inventor of the term, Andrew Huberman, defines it, "limbic friction is how much […] conscious over-ride of your state is required in order to engage in that particular behaviour". (Huberman, Science of Making & Breaking Habits, sequence 0h21'20''–0h21'36''). There are two possible states of the autonomic nervous system that would need to be overcome to perform a habit: a state of anxiousness, the sympathetic division, or a state of calmness, the parasympathetic division. We have to find the right balance of the activation of these two autonomic branches in order for us to be in the suitable mode to carry out a particular habit. The more profoundly a habit is established the lower amount of limbic friction encountered to perform that action. As a habit starts to form part of our identity its limbic friction decreases. A strong habit is a consistently performed habit whereas a weak habit is an inconsistently performed habit. A habit that is preceded by a strong craving, that leads to a large release of dopamine, has a lower threshold to act on the craving.

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[6] A cell assembly refers to all the involved neurones.

[7] Multiple interconnected neurones form a pathway.

1.3 Strategies that influence the ease of habit formation

1.3.1 Habit stacking

The concept of habit stacking, is a strategy developed by BJ Fogg, which he refers to as the "Tiny Habits Recipe". It is the process of latching a new habit onto an existing habit, which then serves as the foundation of a not yet acquired habit. This strategy takes advantage of an action we want to do and combining it with one we need to do. It is important that the less preferred action is completed prior to the completion of the established action. This necessary order of actions in habit stacking applies the Premack's Principle[8]. Habit stacking is an implementation intention[9] with a pre-existing habit used as guidance on time and location. By giving clarity to the course of an action, on when to incorporate the desired habit, the mental friction is reduced in advance of the action. The new habit will then be associated with the pre-existing habit such that the existing habit will be perceived as the trigger for the new habit. To employ this strategy an already established habit has to be identified to be used as the basis layer. The desired behaviour is then stacked onto the established one. Leveraging the pre-existing habit as an anchor for the desired habit only works with repeated action.

The Diderot effect, describes the phenomenon that when we take a step in one direction a further step will follow more easily in the same direction. This phenomenon was first seen in spending patterns, where purchasing one item would ease the way for similar purchases. Applied to the principle of habit stacking, once the first habit is completed, all the linked habits should naturally follow - but if the first habit is not completed, all the linked habits tend to be forgotten as the chain reaction cannot take place. (cf Clear, 2019, Atomic Habits, p70-79, p110-111, p160-163, p279)

1.3.2 Task bracketing

Habits are generally looked upon as single closed actions, but we are able to break habits down into various segments or lengthen the time horizon over which we look at a habit as being completed. To understand the underlying structure of task bracketing, we need to look at how the brain addresses action and inaction or suppression of behaviours. The neural circuits in the dorsolateral striatum[10], are linked to action execution and suppression. Activating this brain region in the context of habit performance, increases the likelihood of the habit to be taken up swiftly and more importantly, for it to become a long-term embedded habit. This particular region is also active during on- and offset of habit execution.

Taking a look at an extended timeframe lets us positively anticipate the initiation and the ending of the habit. The reward before as well as after the habit makes sure the habit loop is closed, so that the particular habit is inclined to be repeated. To further enhance this effect additionally positioning dopamine provoking actions just before and after a habit makes us associate the frame of that particular habit with physical rewards.

Using known rewards as the framework should speed up the habit formation process in a sustainable way. When introducing a desired habit into a system of existing ones, there is a

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[8] Premack's Principle states that when a disliked action is paired with an enjoyed habit, the likelihood that the less preferred action is completed is higher than if it were on its own.

[9] Implementation intention is a plan that specifies the intention on how to implement a certain behaviour.

[10] The dorsolateral striatum is a subdivision of the basal ganglia, which are located in a central region of the brain. (cf Aglioti,23.12.97, The Role Of The Thalamus And Basal Ganglia In Human Cognition)

possibility that the whole bundle is ritualised, rather than the individual habits being seen as chores. (cf Tan, 2022, New year, new me? How to make habits stick)

1.3.3 Motivation

There are many parameters that influence how strong a habit is and how easily a habit can be formed. More often it is solely the strength of the reward, which is the driving factor indicating whether a habit can be successfully formed and sustained. It is the expected or perceived outcome that motivates us and as a result drives habit pursuit. Our emotions label actions for us and let us evaluate from a distance if the emotions matched to an event are the change in our internal state that we are looking for. Motivation makes us take action towards the feelings linked to the reward we desire.

To maintain motivation to complete habits, the choice of habit in the optimal zone of difficulty can help us manage avoiding boredom and failure. The principle referred to as the Goldilocks effect says that we tend to gravitate towards an optimal balance between two extremes. We choose the level of difficulty of our task at just below the verge of failure. Choosing the difficulty zone at this optimum makes sure that we do not outgrow our goals but always stay engaged in our tasks. Always having to put in effort ensures that we become more skilful at a certain task. Improvement enables the sensation of satisfaction and lets us strive for better rewards. The sweet spot is where we shift into a flow state -> full immersion in a performed task. Finding continuous forms of novelty can help us stay engaged in our tasks.

Motives of human nature stay consistent, but as there are many solutions to the same problem, our paths vary accordingly. On an evolutionary basis survival was the main focus and therefore all behaviour revolved around it. All of the underlying motives cater to the most fundamental survival needs like food, water, shelter, reproduction as these rewards boosted the chances of survival. Whereas our environment is constantly changing, human strategies of survival remained rather constant as our brains have not changed much in the last 50'000 years.

As nutrition and water have not always been at our disposal in abundance, humanity has devoted a substantial part of its energy to gather these vital resources in order to minimise uncertainty. To fuel all of these plans and processes, gathering and conserving was the key to survival. Social aspects had high values to connect individuals into a network, which secured reproduction. We try to fit in with our environment to gain social approval but once we have established a secure position in our community, we try to attain a higher status and enjoy the better treatment that accompanies it. (cf Clear, 2019, Atomic Habits, p48, p101-134, p231-237),(cf Sridharan, 2013, The Goldilocks Effect, in Think Insights), (cf O'Bryan, 2021, What Is Motivational Enhancement Therapy (MET)?)

2. Methods

2.1 General information

In order to analyse the formation of habits and attempt to find out what variables play a decisive role in the process; I conducted a study with a total of 132 volunteers. By applying the concept of a randomised controlled trial, I evenly distributed volunteers into five groups at random. This approach aims to represent the variability of the actual population in the individual groups. There was some balancing needed so that possible clutters of a specific parameter could be redistributed evenly. Every group, ranging from 21 up to 30 individuals, was instructed differently in order for me to be able to analyse and evaluate various implementation strategies.

The volunteers did not receive any information as to what the nature of my study was. If desired, the volunteers were informed of the researched topic after they completed or failed the whole

course of the study. All of the groups were required to pursue the same task and were not allowed to use any auxiliary tools as for example alarm clocks or written notes.

The study was set up over a period of 21 days split into three consecutive seven-day periods. 21 days is a short interval that gives us an insight into goal-based[11] habit formation. This timespan additionally allows us to put the widely broadcasted 21 days to the test. The main focus of my research was to see whether or not the participants attempted the task or not. (cf White, Sabarwal, 2014, Developing and Selecting Measures of Child Well-Being), (cf Hariton and Locascio, 2023, Randomised controlled trials – the gold standard for effectiveness research)

2.2 Groups

I categorised the volunteers into one control group and four intervention groups. When creating the individual groups, I paid attention to variable isolation in order that the mean error would be minimised and the varying results amongst the groups could clearly be assigned to one concrete predicting parameter. The highest frequency of task completion was limited to once a day. Actions increase their automaticity the more they are repeated not necessarily the longer they have been pursued. Therefore, the frequency of the habit execution, not the timeframe in which the habit has been performed, plays a greater role.

To simulate the norm, I had the control group solve the puzzle once a day without any further instructions. The control group creates a standard and serves as a reference to how well other habit implementing strategies work. Next, I wanted to see the difference motivation could make so I adapted the materials, which I submitted to the volunteers, and added in positive words of affirmation[12] to read through before they headed on towards each task. Otherwise, this group was structurally identical meaning both groups did not have any temporal indications as to when the puzzles should be solved. (cf Hill, 2021, The Benefits of Positive Affirmations)

I based two groups on the implementation strategy of habit stacking. The first habit stacking group was to use one of the strongest habits we have and stacking the specific task on top of it. For this study I used brushing one's teeth as the heavily embedded habit. The second habit stacking group was instructed to use a weak habit as the foundational layer to stack the desired habit upon. They were told to engage in the task during an outside activity. In both of these cases they simply had to execute the desired habit in a timeframe around the basis habit. The last intervention group applied the principle of task bracketing. The frame they were instructed to implement around the task executing was a mental exercise called spotlighting and ingesting a caffeinated drink after they attempted the task. If it was too late in the day, there always was the possibility to just drink a glass of water or any other drink they deemed pleasurable after the habit execution. Now I will briefly explain the science and benefits linked to these two tasks. (cf Volkow, 2015, Caffeine increases striatal dopamine D_2 / D_3 receptor availability in the human brain)

Spotlighting is a technique that bundles visual attention on a specific point. To reduce the difficulty, a variation would be to focus on a round object. It imitates a finishing point that the mind can aim for. This is based on the gradient hypothesis that states "With perceived proximity the amount of effort people are willing to invest to reach their goal becomes larger." Spotlighting creates induced proximity and with that motivation increases proportionally.

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[11] Goal-based refers to outcome focused habit formation. The opposite would be identity-based habit formation, which is only possible long-term as the perception and identity of self have to be altered in order for the desired habits to be part of the new identity.

[12] Positive words of affirmation can have a positive impact on mood and motivation if done properly with conviction.

When consumed responsibly and at a timely hour caffeine can have reaping positive effects. Caffeine, no matter the source, triggers a conservative dopamine release, but more importantly it increases the amount of dopamine receptors and thereby the dopamine sensitivity is elevated (see "Hebbian learning"). That is the reason it can be implemented as a reward even from a biological point of view. (cf Huberman, Balcetis, 2022, Tools for Setting & Achieving Goals, 0h28'25"-0h32'50"), (cf Huberman, 2022, Tools to Manage Dopamine and Improve Motivation & Drive), (cf Akers, 20.11.19, Is Dopamine Fasting a Way to Fix Your Brain or a Sillicon Valley Fad?)

2.3 A brief participant reflection

Of the total of 132 volunteers 49 of them were below the age of 20 and female. In general, all five groups had a solid count of participants under 20 years. The number of participants in each group C, B, M, S1, S2 ranged from 21 up to 30. The age group between 20 and 29 counted 19 individuals. The two age groups ranging from 30 to 39 and 40 to 49 were underrepresented, meaning they each had below 10 participants. Therefore, their curves vary highly and easily show extremities. The next age category from 50 up to 59 counted 17 and the last group above the age of 60 had 14 participants.

2.4 Puzzle

I needed my volunteers to complete a task, which is simple enough as to not be too demanding for the participant, yet difficult enough for them to actually apply some effort. The task chosen for the participants would let me track their individual habit formation and help me determine crucial aspects of habit formation. My solution was to have the volunteers solve hidden object pictures as their daily task. They are visual problem-solving tasks, where an object is hidden in plain sight. Such puzzles are known to enhance cognitive abilities and stimulate the brain and are a fun way to challenge ourselves. There is no need for any explanation, they are similar to problems we have previously encountered and only need limited introduction. These puzzles would generate some form of notable reward from completion, which in this case is in the form of satisfaction of completion, with sufficient feeling of failure when not attempted but also when not solved. (cf Ludwig, Hartmeier, 2019, Forschen, aber wie?, Chapt.1 and 5)

2.5 Data collection

Each volunteer received 21 puzzles and three surveys that helped me gain an accurate understanding of their progression. The data was recorded through two methods: 1) digitally through the tool Survey Monkey and 2) physically. After each week they had to fill out the surveys with the according data.

The surveys additionally functioned as a habit tracker, as the performance of the task was being recorded and could lead to the execution of the habit itself. To be able to match all three surveys to one single participant I needed a few personal specifications such as age, gender and the implementation strategy. To figure out the latter detail I had to ask indirect questions. To further explain this: the control and extra motivation group received the same survey so in order to figure out what implementation strategy they were applying, my question was directed towards the number of puzzles on a single page, as the extra motivation group only had two instead of four like the rest of the groups. The other three groups also filled out the same shared survey and had to let me know what activity the puzzle attempting was connected to.

The completed questionnaires gave me insight into the attempted days, the motivation and success they felt, if they were able to solve the puzzle in under 30 seconds, if they were able to

solve the puzzle faster than the preceding day and how tricky they felt a puzzle was on a certain day. They could also let me know if there were any valid excuses[13] for being occupied.

The feeling of success was evaluated on a scale of 0 and 1 based on the answers of not really and yes. The difficulty of a particular puzzle was evaluated on a scale of 1-3, and 0 indicating the absence of an answer. 1 corresponded to easy while 2 indicated intermediate difficulty and 3 indicated the level difficult. The anticipation to take on the puzzle was measured on a scale of 1-3 and 0. The scheme ranged from not really, over to okay and finally finishing with bring it on. Any legitimate reasons not to engage in the task were noted by the participants. Say there was a legitimate excuse, a one was aligned to their data. All data was recorded in an excel spreadsheet to assemble all the loose individual data.

I only took hard measurable parameters[14] into consideration as for example age or gender as the list of variables that could make an impact would go on and on. The purpose of my study is to find connections between causalities and outcomes in habit formation. All of the participants' data was collected and is being used anonymously.

In order to reduce any biases that could shift the results direct household members were omitted and I designed the survey questions in a manner that demanded answers on a broad spectrum to keep the actual purpose of the study concealed and therefore ensuring that the participants could not actively work towards improved habit formation.

2.6 Outlook

Based on the behavioural literature that I have consulted to prepare this study; I generally expect a gradual increase of attempts daily with time. Automaticity increases with repetitions so after a while the puzzle solving should become more naturally incorporated into the participants' daily lives and therefore I expect less one-off days that are missed.

All of the intervention groups have an advantage towards the control group so I expect a more stable and additionally faster repetition incline. Motivation is a short-term solution for behaviour change so I can imagine the extra motivation group doing well. The habit stacking groups will probably come in second. The group using the weak habit as the basis layer will most probably suffer irregularity opposed to the strong habit stacking group. As the task bracketing group is concentrated so heavily on boosting dopamine around the timeframe of the desired habit, I expect this group to primarily have positive emotions associated to the task and then as an effect of these emotions I can see this group outperforming the rest.

Furthermore, I expect that participants 59 and older will tend to be more forgetful and will struggle to incorporate the puzzle on a daily basis, whereas I think people younger than 20 will also find it difficult, as they have very variable schedules and will probably not see the continuity, thus their reliability as impaired if they miss a day, in comparison to the reaction of older participants. I do want to emphasise that the nature of my study was in nobody's knowledge but being reliable and attempting the puzzle can be an indication of being on the

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[13] For an event to be a legitimate excuse to be occupied I only required volunteers to put down a specific reason for missing a day. Being sick was a separate data point I collected. The legitimacy of a certain excuse is very subjective and therefore differs from person to person. Sometimes despite having an event and thus being occupied some participants still attempted the puzzle. So additionally, to the subjectiveness of something being legitimate or not, it is subjective to each individual whether or not they still participated in the study when having a reason not to.

[14] In my paper I will come back to the term ‚parameter' and will use it as an umbrella term for all measurable variables in my study as for example the five groups, age categories and gender

ball. Particularly the elderly get doubted more and more therefore this can be an opportunity to show off their strengths and demonstrate their solid memory. I cannot predict any differences in gender as the habit formation process does not seem to differ between genders.

In short, my hypothesis is that there will be a gradual increase in attempts daily and that participants categorised into the task bracketing group or participants between the age of 20 and 58 will have a higher rate of daily attempts and that gender will have close to no impact on habit formation.

3. Results

3.1 General overview

I was able to record a dense amount data per participant and will structure the presentation of my results starting with a general overview and then continuing by going into the details of my findings. I gathered 132 volunteers to take part in my study and 88 ultimately attempted the puzzle on the first day. Volunteers that only signed up but did not however participate in the study, did not show any tendencies towards a certain parameter. Therefore, I derive from this information that the lack of participation is random and has nothing to do with the group they were assigned to, their age or gender. Of those who participated 23 belonged to the group B, 16 each to the groups M and S1, 15 to the group C and 18 to the group S2[15]. The age categories were more unevenly represented. The age category below 20 (u20) had the highest participant count at 46. Age categories older than 19 (>19) and older than 49 (>49) both counted 12 participants. Next up is the category 59 and upwards (>59) with a total of 10 participants. I have decided to merge age categories above 29 (>29) and above 39 (>39) together as they only had 4 participants each and, in this format, this combined category is more easily comparable with the other age categories. Of the 88 participants 61 were females and 27 were males. All of this information regarding the participants is given in the table below. If a participant chose a fixed starting day but then forgot to attempt the activity on that day, it is possible that the same participant attempted the task on a different day and therefore the percentage of the daily attempts can exceed the first day attempts of 100 percent. I want to clarify that all of this data solely refers to the first day and as I will now lay out and discuss, will rapidly deteriorate.

The general trend of the study is a steady decline ending on an overall rate of 21 percent of participants executing the task on the last day. All groups, age categories and both genders experience a recovery of the number of attempts towards the end of the first week (day 5-8). In the frame of my work, I will refer to this phenomenon as the second attempt[16]. The second and third week have rather flat curves, meaning that the larger differences happen predominately after each completed week or already in the first week. There is a large drop of nearly 20 percent of daily attempts after seven and fourteen days, so after each filled out survey. The half-life of the daily attempts was around eight days but there are certain groups/categories that outperform this mere week.

The success of the participants seems to roughly follow the progression of the daily attempts though how these two curves progress is highly variable depending on the parameters. Often

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[15] Group C refers to the control group, group B to the task bracketing group, group M to the extra motivation group, S1 to the strong habit stacking group and S2 to the weak habit stacking group.

[16] The second attempt only refers to the number of daily attempts. The success felt is not taken into consideration for this term. This second wave takes part between day 5 and 8 and shows a climb in daily attempts. After the increase a steep decrease follows.

the success felt runs above the course of the daily attempts. The graph of the successes is more volatile in comparison to the daily attempts graph. The drop after each week can also be seen in the successes. After the second week the two graphs line up nicely (see Graph 1 attempted and success). The success does vary depending on how the individual puzzles' difficulty was evaluated. Easy puzzles kept the daily attempts and feeling of success progression close. An engaging difficulty level raised the level of success and an advanced difficulty level lowered the feeling of success (see Graphs 7a/b/c in the appendix).

3.2 Overview of the groups

The control group experiences the second attempt after the fifth day but after the peak on day 6 back up at 93 percent there is a gradual decline down to a third after two weeks. The second week has the largest decrease in daily attempts whereas the last week has the flattest progression. 14 percent of the participants on the first day completed the task on the 21st day.

The progression of the extra motivation group is highly variable. There is a big decrease of daily attempts from day two to four down to 32 percent. The second attempt gets a lot of the participants involved again so that three quarters of the first day participants execute the task on days six and seven. The half-life is passed after the second week. The participants executing the task on the last day make out 32 percent of the first day participants.

The next group I will assess is the task bracketing group. This group does not just have the single second attempt but rather 4 individual recoveries. The first peak is on the fourth day, with a crash on the following day of more than 50 percent. The second attempt seen across the entire study builds up over the period of day 5-7. The last two recoveries take place in the last two weeks. The first peak however has the greatest in- and decrease. On the last day the daily attempts slightly increase up to 14 percent of the first day participants.

I will be taking a look at the strong habit stacking group before switching to the weak habit stacking group. After the slight second attempt after day six there is a second recovery on day 13 which is double as big as the first recovery (12 percent opposed to 6 percent in the first week). The greatest declines are between days 2-6 (43 percent) and days 13-17 (37 percent). The second and third week are relatively stable within the course of each week. 13 percent of the first day participants completed the puzzle on the last day.

The weak habit staking group maintains a rather high number of attempts throughout the course of the study. The percentage of participants does not dip below 100 in the first three days. The second attempt portrayed by this group makes the daily attempts climb by 16 percent. The decline however at the beginning of the second week is a 40 percent drop. There is a second recovery at the end of the second week which is exceeded by the immediate decrease at the beginning of the third week. The third week almost shows horizontal progression but for one day missed by one participant. This group finishes at a rate of 34 percent.

Graph 2a attempted by Group
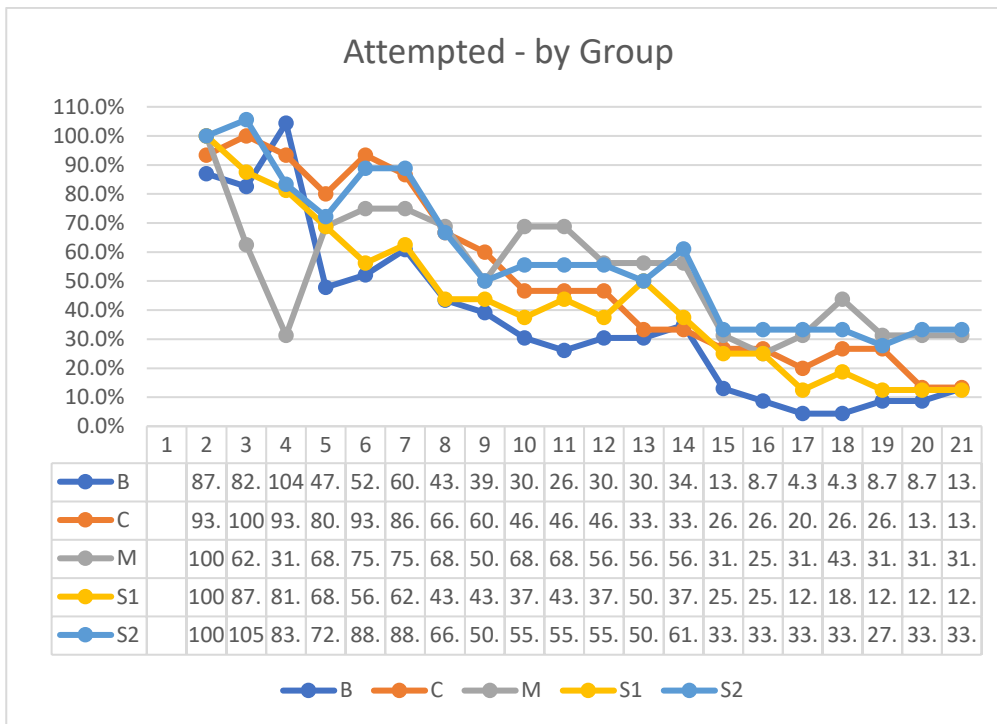
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
B		87.	82.	104	47.	52.	60.	43.	39.	30.	26.	30.	30.	34.	13.	8.7	4.3	4.3	8.7	8.7	13.
C		93.	100	93.	80.	93.	86.	66.	60.	46.	46.	46.	33.	33.	26.	26.	20.	26.	26.	13.	13.
M		100	62.	31.	68.	75.	75.	68.	50.	68.	68.	56.	56.	56.	31.	25.	31.	43.	31.	31.	31.
S1		100	87.	81.	68.	56.	62.	43.	43.	37.	43.	37.	50.	37.	25.	25.	12.	18.	12.	12.	12.
S2		100	105	83.	72.	88.	88.	66.	50.	55.	55.	55.	50.	61.	33.	33.	33.	33.	27.	33.	33.

Description: the progression of the daily attempts by all groups over the course of three weeks.

In Graph 2a, we can see the general downwards trend with the second attempt towards the end of the first week, however there are variations as up to which degree the tendencies are portrayed by the different groups. In the first week all strategies applied seem to have an acclimation period with a lot of fluctuation. In particular the extra motivation group experiences a huge drop, which however can be corrected just as rapidly and in time for the second attempt to occur. The strong habit stacking and the task bracketing group along with the control group can be made out as the most poorly performing groups relatively early from the second week onwards. The task bracketing group demonstrates a similar pattern of progression as the weak habit stacking group but at a lower percentage. In the end there are two clusters of the attempt of the puzzle on the last day. One is formed by the weak habit staking and the extra motivation group at around roughly a third of the first day participants. And the second cluster, where the other three groups end up, is located far lower at just below 15 percent.

The success by the participants of the control group is generally higher than the number of daily attempts. On the last day a third of the first day participants report a sensation of success. In the extra motivation group the success seems to exaggerate the tendencies of the daily attempts. 30 percent of the first day participants succeed on the last day. The task bracketing group exhibits a feeling of success far higher than the daily attempts. This group finishes the study with 23 percent of successes. The strong habit stacking group recorded data showing a lower feeling of success than the daily attempts. The successes on the last day are by far the lowest compared to the other groups at 10 percent. In the weak habit stacking group the successes are lower than the daily attempts throughout the study. The success on the last day by this group was at 29 percent (see Graph 2b).

3.3 Overview of the age categories

Next, I will take a look at the performance of the different age categories starting from the youngest to oldest category. Volunteers aged below 20 years old are referred to the category u20. The graph of daily attempts declines rapidly and then progresses at a lower rate. The last two weeks are very stable within themselves when viewing the weeks as singular completed units. There are three measurable drops, after day 2, day 3 and day 14. On the last day only 14 percent of the first day participants attempt the puzzle.

The age category above 19 years old (>19) starts off very strong but then suffers impactful drops after the completion after each of the first two weeks. There seems to be a slump in every week, which can more or less be corrected till the end of the same week. This category does not just have a second attempt but several recoveries spread throughout the three weeks. This category ends the study at 25 percent of the first day participants.

The combined age category from 29 up until 48 (>29 and >39) has a slump just before the second attempt at the end of the first week. The transition between the first two weeks is quite rough with a difference of 50 percent in daily attempts in just a day. The last two weeks are very steady within the progression of the week. There is however another noticeable drop between weeks two and three. The rate of the daily attempts on the last day was also at 25 percent.

The next age category including participants from age 49 up until age 58 (>49) shows a lot of movement of the daily attempts in the first week and a substantial transitional change after the second attempt. After the first week the progression of the graph is almost flat. All participants holding onto the daily execution until the last week make it through the last week without fail, meaning 25 percent of the first day participants were registered on the last day.

The final age category is only confined from the bottom at 59 years (>59). This category does not show a second attempt peak however this category has a continually flat decrease in its progression over the course of three weeks, that really makes this category stand out. The daily attempts only dip below the 50 percent line on the last day. This category finishes the study at 40 percent of the first day participants.

Graph 3a attempted by Age
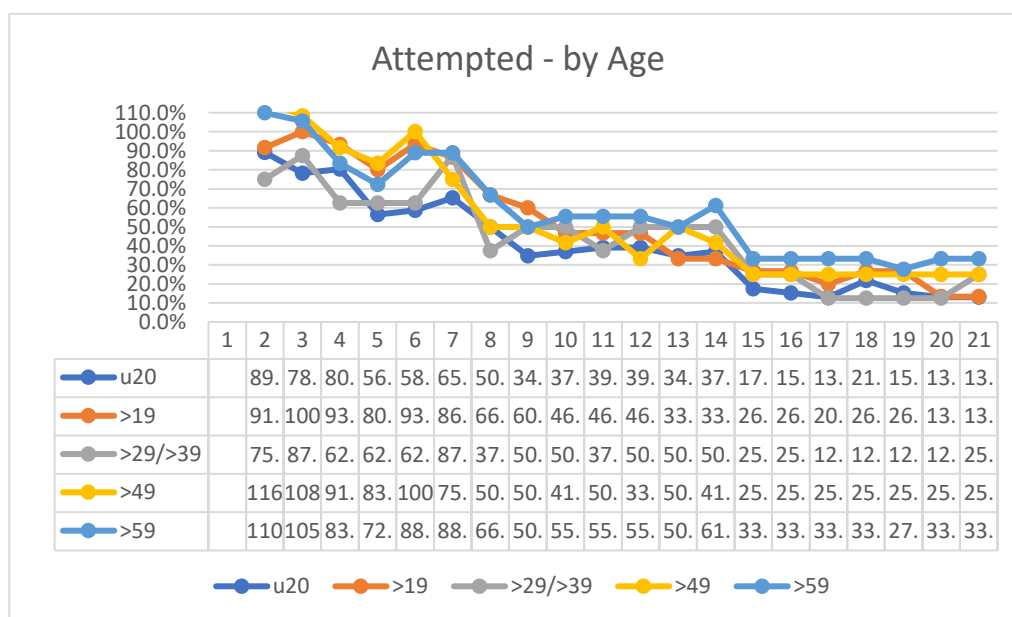
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
u20		89.	78.	80.	56.	58.	65.	50.	34.	37.	39.	39.	34.	37.	17.	15.	13.	21.	15.	13.	13.
>19		91.	100	93.	80.	93.	86.	66.	60.	46.	46.	46.	33.	33.	26.	26.	20.	26.	26.	13.	13.
>29/>39		75.	87.	62.	62.	62.	87.	37.	50.	50.	37.	50.	50.	50.	25.	25.	12.	12.	12.	12.	25.
>49		116	108	91.	83.	100	75.	50.	50.	41.	50.	33.	50.	41.	25.	25.	25.	25.	25.	25.	25.
>59		110	105	83.	72.	88.	88.	66.	50.	55.	55.	55.	50.	61.	33.	33.	33.	33.	27.	33.	33.

Description: the progression of the daily attempts by all age categories over the course of three weeks.

As demonstrated in the previous Graph 3a, the only age category that does not experience the second attempt is category >59. The stability of the progression of the daily attempts is a characteristic feature of nearly every category. Age category >19 does however experience a slump in every week. In contrast the first week shows extreme variations, which can be seen in every age category but for the oldest category. The transitional changes between each week seem to have quite an impact on all categories except the oldest. When viewing the daily attempts of the last day we can see a rising rate with increased age. The oldest age category visibly outperforms all other categories with a rate of 40 percent. Age categories >19, >29/>39 and >49 form a cluster at around 25 percent. The remaining age category u20 had a limited attempt rate on the last day with only 13 percent of the first day attempts.

The success by the age category u20 always exceeds the daily attempts. The levels of success remain high for the first two weeks but in the last week there is a collapse of around 30 percent. The success on the last day is at 20 percent of that for the first day. In the age category >19 the successes exaggerate the progression of the daily attempts. The drops on days 12-13 and 17-18 are the perfect examples of this exaggeration. The sensation of success is by 15 percent of those who success on the first day. Participants between 29 and 48 tend to experience less success than the count of their daily attempts. This merged category ends the study with a rate of feeling success at 15 percent. The feeling of success tends to remain close to the count of daily attempts in the age category >49. These participants report a success level at 23 percent of the first day success. Unlike the daily attempts graph the progression of the success is very volatile in the oldest age category (>59). Until day 10 the success is very high but then suddenly takes a dip down to 20 percent on day 12. On day 13 there is a 120 percent increase from the preceding day. The last week has a very turbulent progression of the feeling of success which then lies at 80 percent on the last day.

3.4 Overview of gender

The next and last parameter that I will be looking at is gender. Females tend to have a higher rate of daily attempts but otherwise the pattern of the progression of the daily attempts between the two groups is nearly the same. On the last day of week two females exhibit a slight increase in daily attempts while males have a slight decrease. The daily attempts on the last day are slightly higher in females than in men (23 vs 15 percent).

Comparing the sensation of success shows a general high rate of success in females and rather low and volatile progression in males. The general pattern of both genders is relatively similar. The report of the success on the last day was around 25 percent for both genders (see Graphs 4a/b in the appendix).

3.5 Overview of legitimate excuse and sickness

Coming to an end of the results section I will briefly look at the impact an event or sickness had on the daily attempts. The according Graphs 5a/b and 6a/b can be found in the appendix. As the sum of daily attempts decreases towards the end of the study so does the number of the legitimate excuses. The percentage of legitimate excuses given when the task was not attempted in relation to the total of participants who did not attempt the task, decreased towards the end of the study. But there was a rise of this percentage at the end of week one and two. Across the three weeks there was a total of 288 legitimate excuses given. A bit more than half of the time a legitimate excuse was given, the participants still engaged in their task. There is a large range of task execution (24-79 percent) despite having a legitimate excuse, which is randomly distributed across the three weeks, so a likelihood cannot be assigned to the task execution based on in which week the legitimate excuse was given.

Those who reported being sick tended to miss a day. To say this in numbers 65 percent of participants feeling unwell did not execute the task. In total there were 63 sick days. There seems to be a higher tolerance at the beginning of the study whereas in the last week being sick meant skipping the task execution. The percentage of reported sickness when the task was not attempted in relation to the total of participants who did not attempt the task decreased towards the end of the study.

4. Discussion

4.1 Statistical significance

It should be mentioned that my study only shows a sample of a large heterogeneous group of individuals, so that viewing my study from a larger scope is necessary to properly assign a calculated value to the study and the data derived from it. Tendencies can be recognised but the corresponding credibility increases hugely once there are other studies that have similar findings. The findings of my study on their own are still sufficient to base broad conclusions on.

Depending on which parameters are looked at, there is an increased amount of confidence in the outcome shown, to further explain: an increased number of participants would lead to increased data collection and therefore the study's statistical power[17] grows. The larger the statistical power, the greater the probability of detecting a true effect[18]. However, we can only ever infer a true effect as it is only based on a small sample of the population. The highest number of participants are in group B, aged below 20 or both genders when viewed on their own, which means the data derived from these specific parameters has the highest statistical significance.

4.2 Struggling to form new habits

With the high decrease of daily attempts over the course of the study and additionally with one third of the volunteers who did not participate in the study whatsoever, we can recognise the struggle and the hindrance people feel to start doing something new, not to mention when trying to form a new habit. It is very prominent that life just tends to get in the way, whether it was indicated in the study by the legitimate excuses and sicknesses or not. How somebody views themselves and how they establish their identity also has an influence on how they participated in the study (or not as the case may be). Somebody who views themselves as a consequent and diligent person, who finds it easy to pick up new activities, is more inclined to try harder at succeeding to form this new habit. Those who do not link themselves to this particular mindset or do not assign a high value to such a task, tend to neglect this task and fail at continuously performing the habit on a daily basis (see 1.1.2). I gather that these volunteers feel a higher limbic friction than those who see a superordinate cause and therefore a higher significance behind the task. If a lot of resistance has to be overcome, it is less likely to perform said activity. This does go to show that as individuals, we all have different levels of in-built limbic friction to each situation presented (see 1.2.4).

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[17] Statistical power is defined as the applicability of the findings of a certain study. It gives the results a frame so to speak and classifies the value of the content. High statistical power indicates that the results are very reliable and display a true effect.

[18] A true effect refers to the real, underlying causative relationship between a predictor variable and a certain outcome.

4.3 General observations

It did however turn out to be true that a steadiness of daily attempts settles in after practicing the new habit for a while, this point seems to be reached after a week. The participants had to get used to their new task. This first week before the steadiness sets in can be described as the acclimation phase.

With the general observation that the success progression was rather volatile, all kinds of underlying causes could provoke this effect. The subjectivity of the assessment of success plays a substantial role. Its subjective nature leads to frequent and exaggerated extremities. However, the difficulty of the puzzles themselves did have an effect on the level of success felt too. This is where the Goldilocks effect (see 1.3.3) can be seen, an intermediate difficulty level kept participants feeling successful, which portrayed a positive effect on the daily attempts, but too high or too low a difficulty level and the feeling of success diminished. However, it is not a direct consequence that participants with a high sensation of success performed well or participants feeling little success automatically did bad. Success does promote positive emotions and an association with positive emotions acts as a cultivating reinforcing influence. As this reinforcing influence of success is a beneficial factor for motivation, it helps a great deal in short-term habit formation. (cf Clear, 2019, Atomic Habits p186)

4.4 So why do we fail?

This is down to a combination of our ability and commitment, if we have the ability to perform a task, then our performance is limited only by our commitment to the task. The way we set our priorities is the guiding structure of how much time goes into a certain task. Time can be poured into a habit before we even get into it, in the form of planning the details of the habit. Planning how we want to form a new habit could get us more motivated and could help us realise to plan in adequate rewards to avoid disappointments. A concrete plan cancels out the doubts and the connected negative self-talk we feel at certain stages of the task itself. Incorporating support systems to maintain motivation, manage fear of embarrassment or failure and to hold us accountable, would be another strategy to reduce the human tendency to quit, it could even help combatting forgetfulness. Forming a new habit requires a large amount of discipline, which for the majority of people is difficult to maintain. The biggest impact on the habit formation probably is our identity and how we deal with missing the task once. If we cannot identify ourselves with a habit, we are not truly aligned with it and our lack of commitment will hold us back (see 1.1.2). Another big influence is our way of dealing with missed habit execution. Often, we slip into a vicious circle of letting one miss define us and finding it hard to get back on track again. Feeling unwell or being busy are the superficial symptoms of a systematic way of excusing oneself and avoiding having to realise that we can evade failure by skipping the task. (cf Clear, 2019, Atomic Habits p200-202)

4.5 High levels of motivation or specific planning

It became apparent in the results section that not all groups did equally well. The extra motivation and the weak habit stacking group outperformed the other three groups by quite a way (see Graph 2a). Now the question arises why it played out like the way that it did.

For an implementation strategy to be of any use it would have to do clearly better than the control group, which solely served as a reference to show the standard progression. With the help of my study, we can gain insights on what implementation strategies might have a positive effect on successful short-term habit formation. If we were to look at a longer time horizon, the order of the performance ranking could may well change. Short-term it seems that it either suffices to have high enough motivation levels, or to combine the desired habit with a weak

pre-existing habit. I will have a look at a few aspects surrounding motivation before I go into depth of the effect habit strength has on habit formation.

4.5.1 Motivation and volition

Motivation is easily influenced and therefore motivation levels have a large range even over a short period. If we feel good doing something, we crave that same reward from time to time again (see 1.1.1). For short periods motivation is powerful enough to keep us going however I doubt that given the high variability of motivation that this strategy is sustainable in the long-term. Nevertheless, I do think it is possible that the advanced step of motivation, that is more deeply embedded in our being, could be beneficial to quickly form lasting habits. By practicing motivation, every time a specific habit is performed, this motivation can expand itself into volition. Volition is an internal force that no longer only exists as a wish but as an established intention to do something. Volition transforms goals into results, it then forms part of our identity, where we are no longer just in a motivated state, but we are actually being driven by willpower towards the desired result.

A study promoting exercise participation was conducted in 2010 counting 248 participants had a similar setup to my study but there were only two intervention groups and one control group. The first intervention group received extra motivation in form of articles on medical benefits of exercise. The second intervention group received the same motivation exposure. The second group had to make a concrete plan when they would engage in exercise. The study was conducted over a two-week period with 3 reports to measure exercise participation. The motivation group did not show any substantial increase in exercise, whereas 91 percent participants of the volitional group however took part in exercise, in comparison to the below 40 percent participation (cf Milne, 2010, Combining motivational and volitional interventions to promote exercise participation: protection motivation theory and implementation intentions, https://pubmed.ncbi.nlm.nih.gov/14596707/)

This study puts motivation and volition into an understandable context and gives us an insight of how a longer-term progression might look like, just by comparing these two groups. Additionally, it shows us how these two implementation strategies worked with desired habits, that require us to overcome a higher limbic friction. The study also suggests that the weak habit stacking group might eventually exceed the extra motivation group if I were to extend the duration of my study. This study cancels out the variable of motivation and could establish a dominance of the volitional group. However, as I decided to test motivation against other groups, I cannot single out if the other groups had a lack of motivation.

4.5.2 Associated emotions to leverage planning

At first it seems paradox that it was the weak habit stacking group that did so well instead of the strong habit stacking group (see Graph 2a). It is plausible that participants who were able to stick to this daily puzzle alongside the weak habit were highly determined and once these two separate actions were mentally associated with each other the probability of executing the entire stack was elevated. Therefore, I believe it is likely that this group could stick to this task over a prolonged duration. To remove a once existing connection between two or more tasks is anything but easy so after a link has been established it is almost natural to maintain a certain task. This could be why the weak habit stacking group did not show any excessive irregularities in the daily attempts. (cf Clear, 2019, Atomic Habits p93)

Brushing one's teeth is a given task we do daily but it can be regarded as a chore. Often, we brush our teeth just before we leave the house and do so in a rush. When we are stressed and our mind is occupied else wise it can slip our mind that we wanted to do a second task stacked onto our normal routine (see 1.1.3). The low success levels of the strong habit stacking group

reflect this accurately. On the other hand, an activity done outside often is a break in our busy lives, which we look forward to. The strong habit stacking group seems to have a strong link between the daily attempts and the successes. It is possible that due to their experience of solving the puzzle whilst brushing their teeth being rather boring, they rationalised their feelings of success and limited their evaluation to whether or not they attempted the puzzle and not including their ability to solve the puzzle in their report.

4.5.3 Specificity of planning

The task bracketing group has a similar progression pattern to the one of the weak habit stacking group. This similarity suggests that it is quite possible that the task bracketing group has potential to improve and become an effective and even sustainable strategy. This group did not however have a proper temporal anchor within each day. Drinking caffeinated drinks does not necessarily have a fixed place in our daily routine.

The extra motivation group neither has a set time, so why do these participants perform so much better? It is possible that only having a halfway suitable time anchor has a negative effect on the daily attempts rather than not having one at all. With a few adaptations of the instructions the systematically high success levels by this group could even boost the effectiveness even higher than the weak habit stacking group. With systematically high levels I am referring to the progression of the two curves with the successes being consequently higher than the daily attempts. Their success levels might be the reason why this group had the endurance for four individual recoveries.

4.6 Three distinct age ranges

The different age categories did show a range of outcomes, the results of which can be categorized into one of three broad life stages. I will properly inspect the results starting from the youngest age category and gradually work my way up.

4.6.1 Students and apprentices

Participants below the age of twenty experienced a rapid decease in daily attempts leading to a low number of attempts on the last day. However, their feeling of success was always higher than the daily attempts. I assess the poorly performance partially as a lack of discipline but especially as a low value allocation to the task. Young people usually live busy lives with changing schedules. To embed a new habit into a varying daily structure is an additional challenge. As for the reliability, tasks done on a voluntary basis often do not get assigned to a high value. Whatever does not have a position high up in our priorities tends to be shifted to the side, where it is potentially forgotten. This age category tends to feel satisfied with themselves, which could be down to them not expecting themselves to be diligent or that they associated success with being able to solve the puzzle, which I expect they were able to do. The peak of the second attempt can be seen delayed by a day in the success. Maybe the number of daily attempts on the day with the highest percentage over the course of the second attempt reminds participants how rewarding it feels to be diligent a day after being back on track. There is a collapse of the success over the transition of both the first to the second and the second to the third week. The first collapse of success is significantly bigger than the decrease of daily attempts over both transitional periods. This might display of the disappointment they, when they failed to stay consistent in their daily attempts.

4.6.2 Embedded in the working life

Age categories older than 19 but younger than 59 had relatively similar results, which can be seen in Graph 3a. All these age categories have a close correlation between attempting the puzzle and experiencing success. This could be a rationalization of being pleased after

performing a disciplined task. It makes sense for these age categories to have similar results because no matter what currently occupies the participants, normally they all are busy with their work lives. The age category >19 experiences a slump in each week. These slumps are always corrected till the end of that same week, which hints towards a calendar entry of the weekly survey. It seems that the age category >19 still exhibits a lack of discipline just like the youngest participants. It is, as if this group forms a bridge between inconsistency and reliability. While the age category >19 forms the link starting out from the youngest group, the age category >49 is the connection leading to the oldest age category. Especially the third week of the >49 age category has a flat progression but also the second week of the same category is relatively steady. This progression looks quite similar to the one of the oldest category. Whoever held out long enough in the category >49 to make it to the last week, was able to remain consistent. All categories but for the oldest exhibit harsh transitional changes between the first and second and the second and the last week.

4.6.3 Approaching retirement

The age category, which is only limited from below at 59, delivered the least expected data. This category showed the highest consistency and reliability and therefore a very flat and continuous decrease. The success rates are exceptionally high. There is however a huge dip in this progression on day 11 and 12, which could be due to two difficult puzzles in a row. This would be supported by the difficulty rating of the puzzles on those two days. Half of the participants attempting the puzzles on days 11 and 12 found the puzzle hard and another third thought they were engagingly difficult. The shooting up of the graph indicates the highly valued reliability. As previously mentioned in the methods section, it is likely that the >59 age category prioritized this daily task to prove they still are reliable and capable of such an activity even with a less anchored daily structure compared to the impact work has.

4.7 Balanced performance in gender

The last parameter I will assess is gender. Even if the daily attempts in men is slightly lower than the ones of females, the pattern of the progression is the same but for two minor exceptions. The larger decrease in attempts by male participants just before the second attempt (see Graph 4a) could simply be down to the statistical power. The number of female participants is double the number of males. So, the mean error in the data males produced is bound to be more impactful than in the data of females. The last day of the second week acts as a defining moment for the rest of the study. It is in a way the railway switch steering towards a higher or a lower count of daily attempts on the last day. The difference in the end is rather small however it is interesting that the pursuit of these tendencies does not change in the last week. The success felt by females is higher than the daily attempts and in males it is lower and highly volatile. It is possible that men rationalised their feeling of success down to whether or not they were able to solve the puzzle. Additionally, we could assume that female participants were more patient or skilful at solving the puzzles and therefore had a higher feeling of success.

4.8 Well-being versus free time

Comparing the impact sickness or an event had on the daily attempts, leads back to the fact that habits are not schedule based but in fact state based. Half of the time an event was reported participants still engaged in the daily puzzle however only a third of the participants reporting feeling under the weather still attempted the puzzle.

4.9 Second attempt

4.9.1 Single peak

The phenomenon I refer to as the second attempt can be seen throughout every parameter but the age category >59. The increase in daily attempts occurs towards the second half of the first week and is followed by a measurable decrease. It is as if a second wave of motivation leads to a peak and then the reassembled effort disappears again just as fast as it came. I have not come across this second attempt anywhere in behavioural literature but I find it to be so distinct that I conclude that there must be something behind it. As this peak is an individual occurrence, is far more exaggerate in percentage than the other recoveries and is also visible across almost all parameters, that it cannot simply be an effect of the weekly survey acting as a habit tracker. It is possible that it is part of a learning curve based on previous mistakes or it might just be the general experience. Maybe the general experience is used as feedback, which made participants rethink and reorganise their priorities. I tend to discredit the explanation based on an altered mental approach, as it only creates a peak and not a successful comeback. They might have felt obliged to their participation in my study and tried to keep their daily attempts upright. On the other hand, they might have even felt obliged to prove it to themselves that they are capable of being disciplined. By redefining a part of their identity, it could be in pursuit of boosting their perception of self. After having proved to themselves that they can indeed properly regulate themselves and adapt, they no longer have to stick to the daily attempts.

4.9.2 Sustainable recovery

For it to have been a sustainable recovery and then continuation of the daily attempts, participants would have to build up resilience and become somewhat flexible to attain personal growth. Passing time and rehearsed action would fuel this process. This would be a long-term orientated learning curve, where facing and dealing with setbacks were properly taken into account and could be dealt with in a revised manner. As habit formation is an iterative process, it is conceivable that with this increased repetition we approximate to a solution or a distinct goal. This mental target could have an attracting force on the participants.

There are many possible reasons why we come across this phenomenon but I think participants proving their point with a burst of motivation would suit the frailty of the recovery best.

5. Conclusion

It is worthwhile reflecting on the short duration of the study. While it is clear that this particular habit cannot be properly formed in the widely recognized 21-day period it remains unclear how long it would take for the participants to reach a steadiness in daily attempts. This steadiness would indicate the participants reached automaticity. Looking at how this habit formation would progress over a longer period would be an important next step to approach.

To come back to my expectations (see 2.6) I anticipated the different implementation strategies to behave differently. That the control group did equally well as the strong habit stacking and the task bracketing strategy partially shows the two impactful causes of failure in habit formation: lack of planning or low motivation levels. While the task bracketing group had high motivation levels, they struggled to stay consistent due to the halfway suitable time anchor. The strong habit stacking group on the other hand seemed to have difficulty experiencing any success. My expectations regarding the different age categories were much more accurate. This could be due to the interactions with these different age categories in society opposed to the implementation strategies. I only misjudged the >59 category. Instead of seeing the continuing

proportional pattern of rising reliability with rising age I associated forgetfulness and increased sickness with this age category. My vast expectations regarding gender were relatively accurate.

5.1 Further studies

The increasing effect of the weekly survey as a habit tracker does raise some speculations: would the drop in daily attempts change if the survey were to be completed after a different number of days: e.g., seven surveys, one every three days? Are we linked more strongly to the seven days of the week? This speculation could be tested in a further study. A different approach to reducing the noise in the data caused by the weekly survey would be to limit the data collection to one long survey after the three weeks. Another idea would be to make the filling out of the survey the daily task to complete. Therefore, there are no interfering factors caused by the data collection. However, this might lead to a data overload. In this potential next study, I would propose designing an app first. With the help of logins, the progression of the different variables could easily be collected and linked to one person.

It could be interesting to look at how the process of habit formation changes in the dynamics of a group, where all of the group members took part. Perhaps this would be possible in a specific community. In that case I would choose a habit that is in their field of interest to ensue motivation levels would be equal in each participant. Therefore, the implementation strategies would be isolated and could be compared more easily. However, it would not be possible to properly see the effect the different strategies actually had on motivation levels like I was in my study.

5.2 What I would change

After I conducted my study, I went over the entire design of the study again with the collected data to help me gain an understanding of how I could improve the design of my study to get access to more reliable and maybe even to more specific data.

One of the things I would change, are the visualization exercises before attempting the puzzle done by the task bracketing group. These exercises might have been too complicated and could be replaced with some easy stretching exercises. This adaptation simplifies the task and therefore the revised task bracketing group might improve its performance.

I would assign a high value to the complete understanding of the instructions and would make volunteers report back to me again before they start the study. I would take this precaution just to ensure that the data could not possibly be distorted.

5.3 Reflection

To take a look back at my project as a whole I honestly have to express how pleased I am with the outcome. It did turn out to be stressful and demanding at times but I had the chance to explore a passion of mine and for that I will be forever grateful. I was able to extensively plunge into my leading question and profoundly establish my understanding of habit formation. I was able to make first hand experiences in the realization of a scientific project and I am very satisfied to acknowledge the fact that I have not just learnt a lot about this topic but additionally learnt new methodical approaches. However, I am most proud of the personal development, experience and sense of fulfillment, that I have made as a person thanks to this project.

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7. Appendix

7.1 Sample of Puzzles

Thank you very much! You are very reliable.
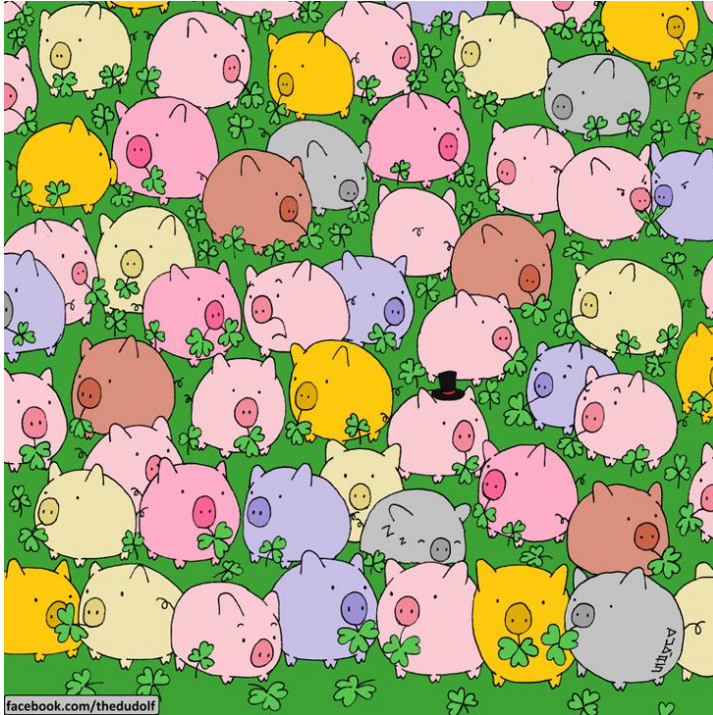
Find the four-leaf clover.

You're doing great!
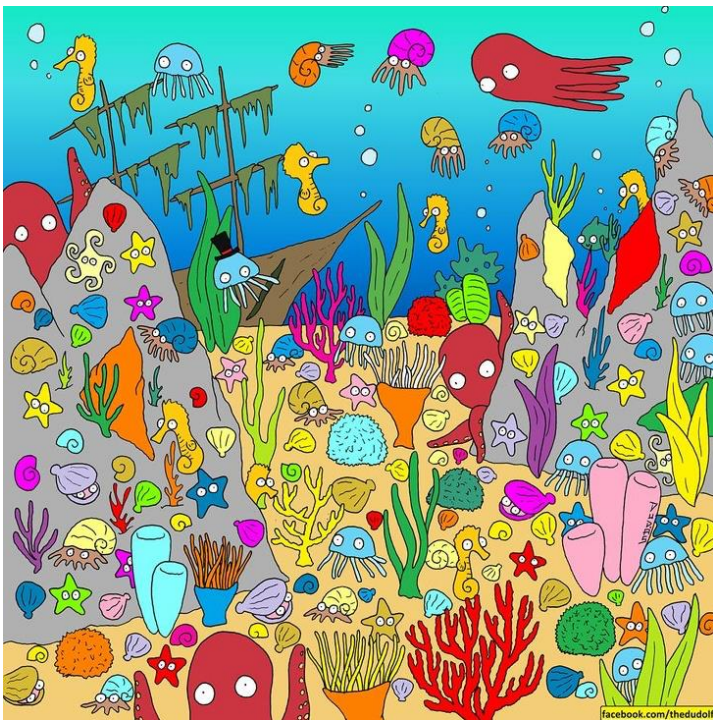
Find the green fish.

7.2 Survey

* 1. Did you attempt to solve the puzzles at the time assigned?

	yes	no
Day one	○	○
Day two	○	○
Day three	○	○
Day four	○	○
Day five	○	○
Day six	○	○
Day seven	○	○

2. If you didn't attempt to solve the puzzles at the assigned time are there any reasons why?

○ I forgot

○ I was busy

○ Sonstiges (bitte angeben)

[   ]

* 3. Were you able to solve the puzzle in under 30 seconds? (If you didn't attempt to solve the puzzle just leave that day blank.)

	yes	no
Day one	○	○
Day two	○	○
Day three	○	○
Day four	○	○
Day five	○	○
Day six	○	○
Day seven	○	○

4. Were you able to solve the puzzle faster than the previous days? (day one in the first week isn't applicable) (If you didn't attempt to solve the puzzle just leave that day blank.)

	yes	no
Day one	○	○
Day two	○	○
Day three	○	○
Day four	○	○

* 5. Rate the difficulty of the puzzles on a scale of 1-3. (1=easy 3=tricky) (If you didn't attempt to solve the puzzle just leave that day blank.)

	1	2	3
Day one	○	○	○
Day two	○	○	○
Day three	○	○	○
Day four	○	○	○
Day five	○	○	○
Day six	○	○	○
Day seven	○	○	○

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* 6. Were you looking forward to attempting the daily puzzles? (If you didn't attempt to solve the puzzle just leave that day blank.)

	not really	okay	bring it on
Day one	◯	◯	◯
Day two	◯	◯	◯
Day three	◯	◯	◯
Day four	◯	◯	◯
Day five	◯	◯	◯
Day six	◯	◯	◯
Day seven	◯	◯	◯

* 7. After solving the puzzles did you feel a sense of achievement (even if only in a small way)? (If you didn't attempt to solve the puzzle just leave that day blank.)

	not really	yes
Day one	◯	◯
Day two	◯	◯
Day three	◯	◯
Day four	◯	◯
Day five	◯	◯
Day six	◯	◯
Day seven	◯	◯

* 8. During this week was there any period where you were feeling unwell/under the weather?

[   ]

9. Was there any standout event that changed your regular schedule this week?

[   ]

10. If there's anything you want to add…

[   ]

* 11. I am in age group…

◯ u20

◯ >19

◯ >29

◯ >39

◯ >49

◯ >59

* 12. I identify as

◯ female

◯ male

◯ non-binary

* 13. I had to complete the puzzles alongside this activity…

[   ]

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7.3 Table of participant data

Participant	Group	Age	Gender	Participant	Group	Age	Gender	Participant	Group	Age	Gender
1	S2	>49	male	45	S1	>49	female	89	S2	>19	male
2	M	u20	male	46	B	>39	male	90	M	>49	female
3	B	u20	female	47	B	>49	female	91	C	u20	male
4	S1	u20	male	48	M	u20	female	92	B	u20	male
5	C	u20	female	49	S1	u20	male	93	S1	>19	female
6	B	u20	female	50	M	u20	male	94	S2	u20	female
7	B	u20	male	51	M	u20	female	95	B	>19	male
8	S2	u20	female	52	B	>19	female	96	S1	u20	male
9	S1	>29	female	53	C	>39	female	97	S1	u20	female
10	C	>19	male	54	C	>59	female	98	S1	>39	female
11	B	>29	female	55	C	>19	male	99	S2	u20	male
12	B	>49	female	56	S2	>19	female	100	S2	u20	female
13	S2	u20	female	57	S1	>49	female	101	M	u20	female
14	S1	u20	female	58	M	>49	female	102	M	>19	female
15	S1	>39	male	59	S1	>49	female	103	B	u20	female
16	B	u20	female	60	B	u20	female	104	S1	>59	female
17	S1	u20	female	61	S2	u20	male	105	C	u20	female
18	S1	u20	female	62	S2	u20	female	106	B	u20	female
19	S1	u20	female	63	S1	u20	female	107	C	>59	female
20	S1	>29	male	64	S2	>19	female	108	B	>59	female
21	B	>49	female	65	B	u20	female	109	S1	>49	female
22	S2	>19	male	66	M	u20	female	110	C	u20	female
23	B	>49	female	67	C	u20	female	111	S1	>49	female
24	C	>19	male	68	M	u20	female	112	C	u20	female
25	S2	>59	male	69	S1	u20	female	113	C	u20	female
26	B	>59	male	70	M	>59	male	114	C	>59	female
27	S1	u20	female	71	B	>29	female	115	S1	>19	male
28	S2	>59	female	72	C	u20	female	116	M	u20	female
29	B	u20	female	73	B	u20	female	117	C	>49	female
30	M	u20	female	74	S1	>59	female	118	S1	u20	male
31	C	u20	female	75	C	u20	female	119	B	>19	female
32	S1	u20	female	76	S2	u20	female	120	S2	>49	female
33	B	u20	female	77	B	>29	male	121	M	u20	male
34	B	u20	female	78	C	u20	female	122	M	>39	female
35	S2	u20	female	79	S2	>49	female	123	S2	u20	male
36	S2	>19	male	80	C	>59	female	124	M	u20	female

37	B	u20	male	81	M	>59	female	125	S2	u20	male
38	M	u20	male	82	C	u20	male	126	S2	>19	male
39	S1	u20	female	83	S2	>19	male	127	M	>49	female
40	S2	>19	male	84	M	>39	male	128	S2	u20	female
41	B	>19	male	85	M	u20	female	129	C	u20	male
42	B	u20	male	86	C	u20	female	130	S1	>59	female
43	S2	>49	female	87	S2	>29	female	131	C	u20	female
44	S2	u20	female	88	B	>19	male	132	S1	>59	female

7.4 Graphs

Graph 1 attempted and success
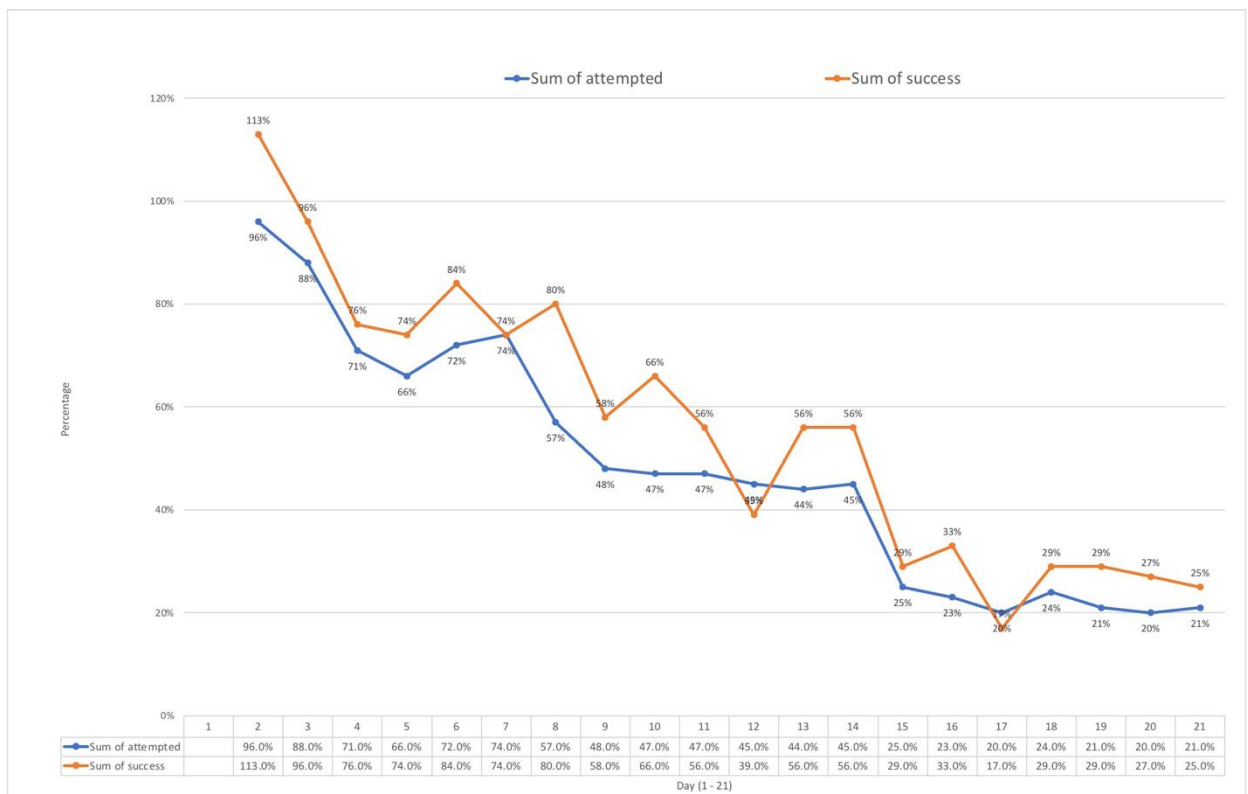
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Sum of attempted		96.0%	88.0%	71.0%	66.0%	72.0%	74.0%	57.0%	48.0%	47.0%	47.0%	45.0%	44.0%	45.0%	25.0%	23.0%	20.0%	24.0%	21.0%	20.0%	21.0%
Sum of success		113.0%	96.0%	76.0%	74.0%	84.0%	74.0%	80.0%	58.0%	66.0%	56.0%	39.0%	56.0%	56.0%	29.0%	33.0%	17.0%	29.0%	29.0%	27.0%	25.0%

Description: we can see the progression of the daily attempts and the success by all participants over the course of three weeks.

Graph 2a attempted by Group
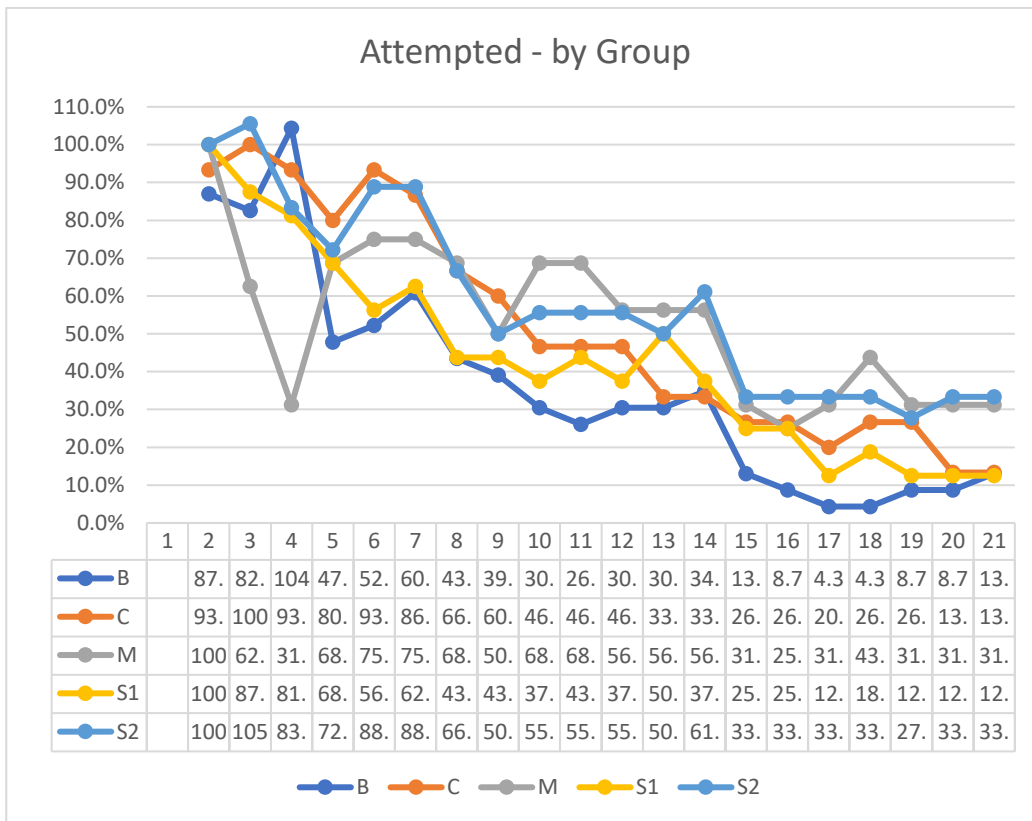
Description: the progression of the daily attempts by all groups over the course of three weeks.

Graph 2b success by Group
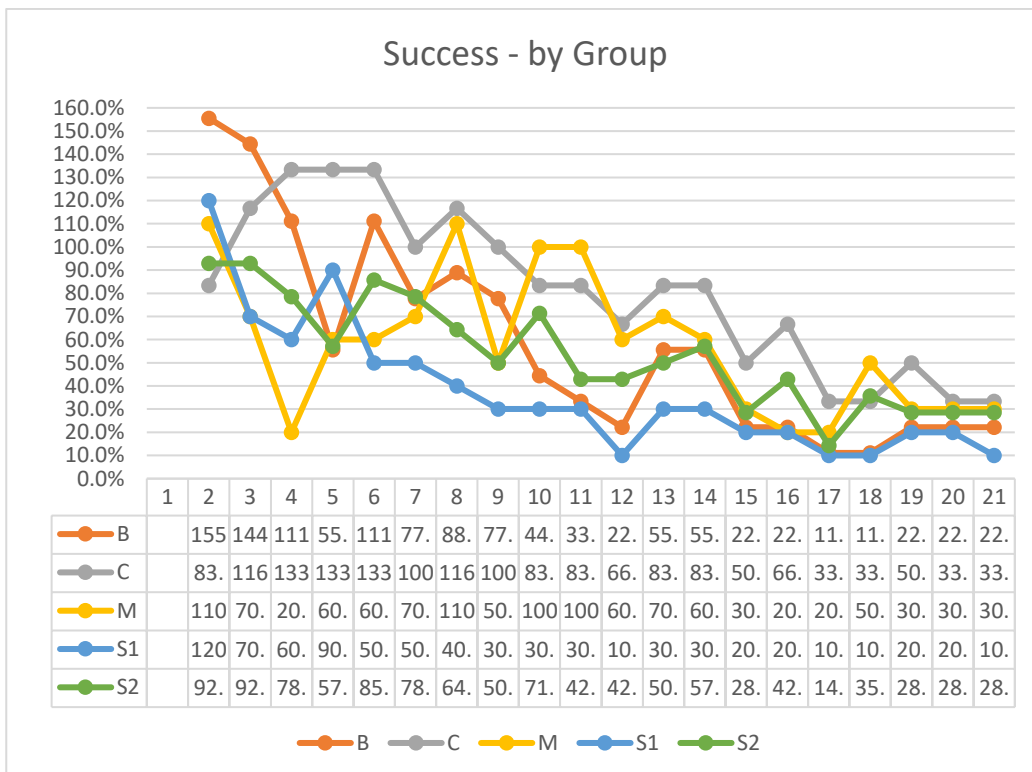
Description: the progression of the success by all groups over the course of three weeks.

Graph 3a attempted by Age
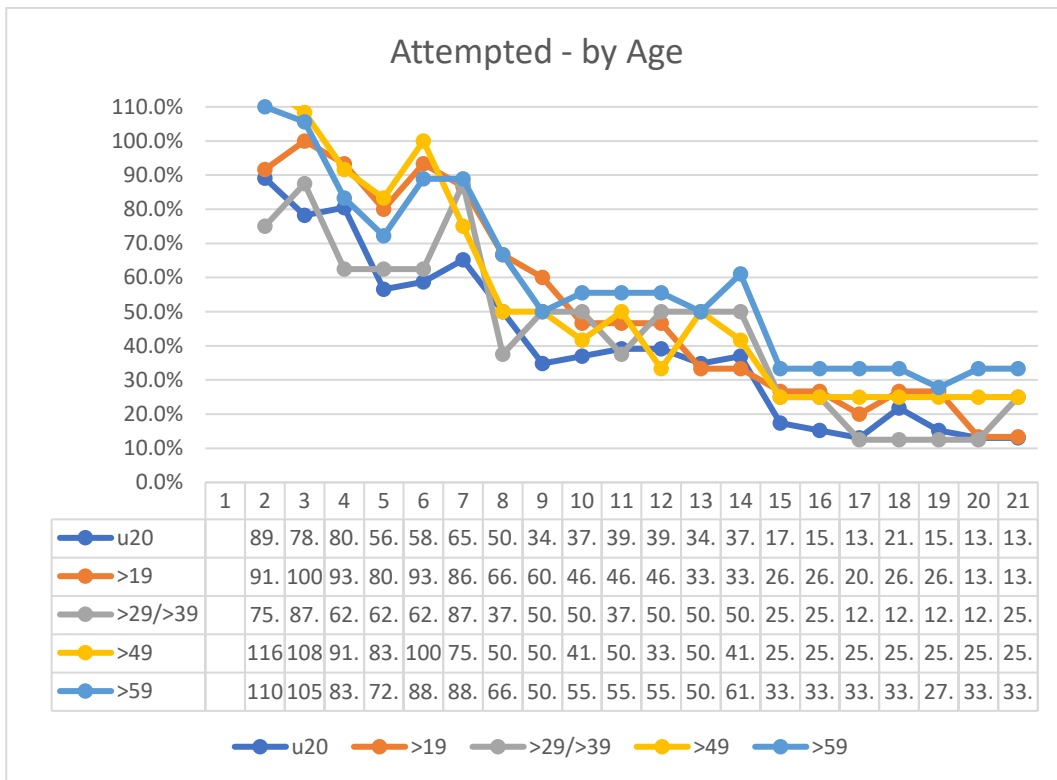
Description: the progression of the daily attempts by all age categories over the course of three weeks.

Graph 3b success by Age
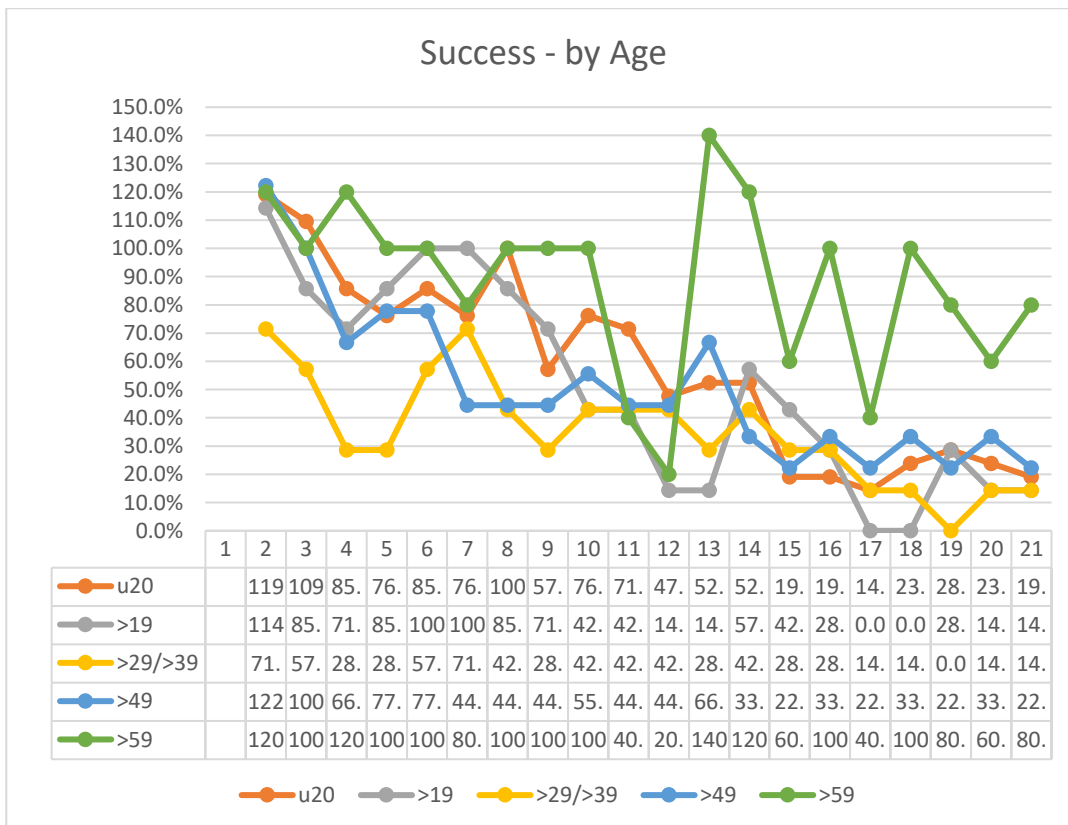
Description: the progression of the success by all age categories over the course of three weeks.

Graph 4a attempted by Gender

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Female		98.	86.	82.	68.	72.	73.	59.	49.	49.	49.	45.	44.	47.	27.	26.	23.	26.	23.	21.	23.
Male		88.	88.	77.	59.	70.	74.	51.	44.	40.	40.	40.	40.	37.	18.	14.	11.	18.	14.	14.	14.
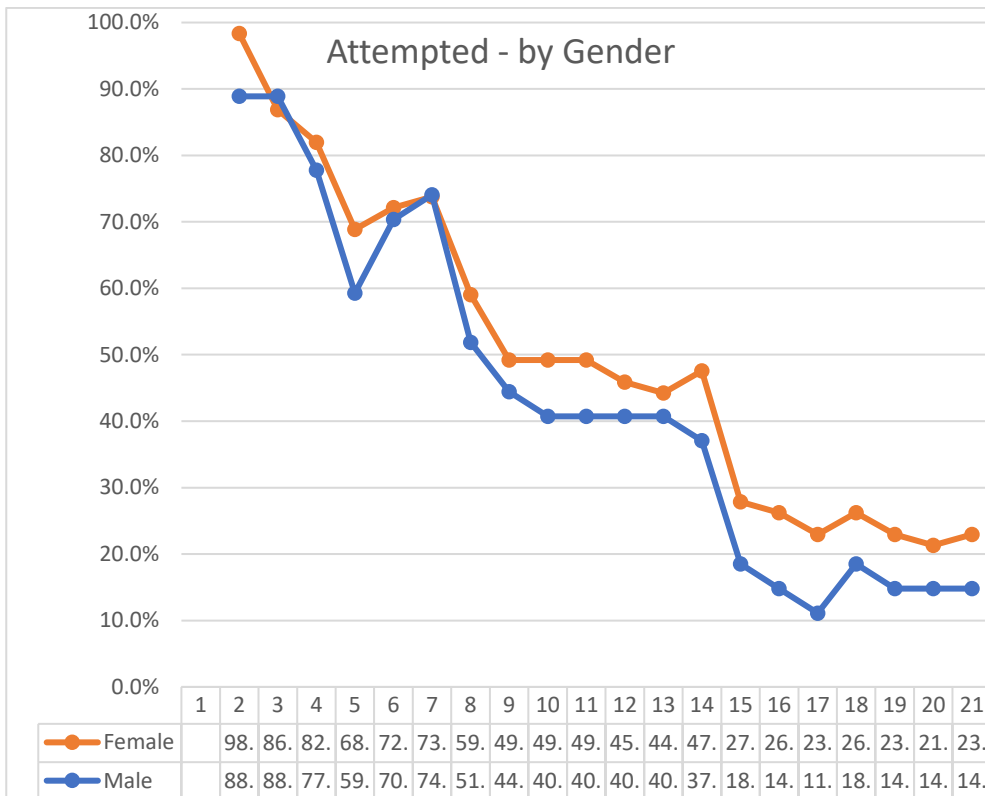
Description: the progression of the daily attempts by gender over the course of three weeks.

Graph 4b success by Gender
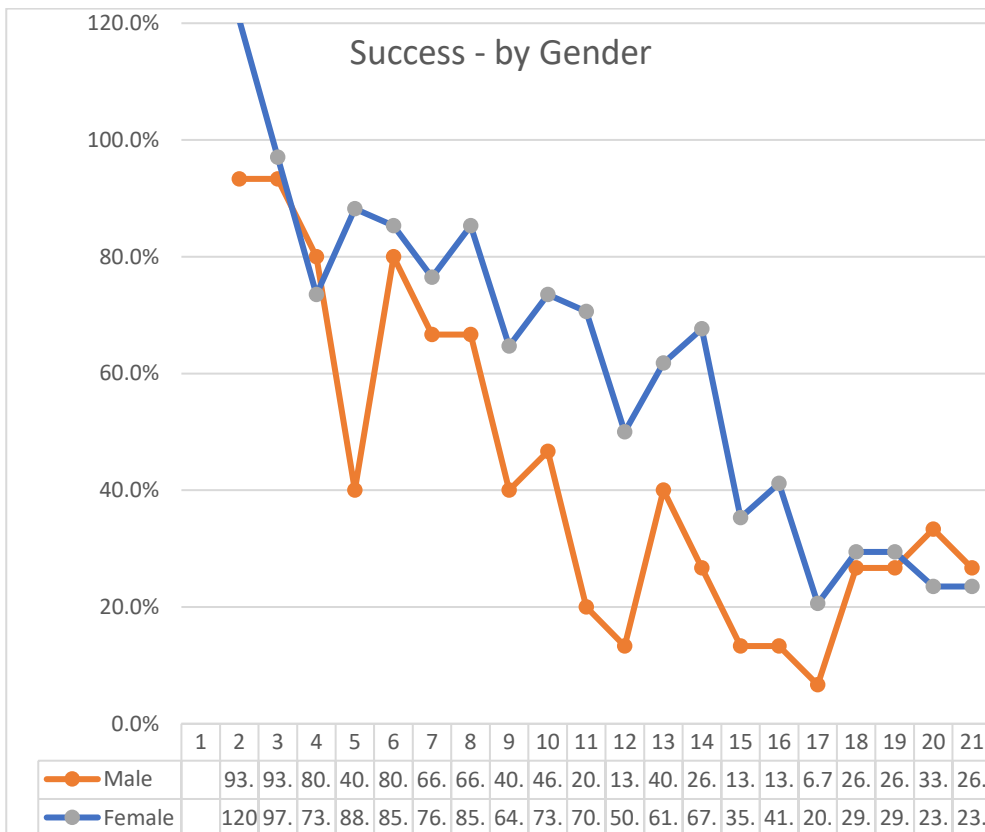
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Male		93.	93.	80.	40.	80.	66.	66.	40.	46.	20.	13.	40.	26.	13.	13.	6.7	26.	26.	33.	26.
Female		120	97.	73.	88.	85.	76.	85.	64.	73.	70.	50.	61.	67.	35.	41.	20.	29.	29.	23.	23.

Description: the progression of the success by all age categories over the course of three weeks.

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Graph 5a legitimate excuse and attempted

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Sum of Attempted	18	10	13	6	5	8	13	10	7	6	7	7	6	9	3	3	2	3	3	2	3
Sum of Legitimate Excuse	26	15	18	19	21	20	24	13	13	13	14	16	16	17	5	6	7	5	7	6	7
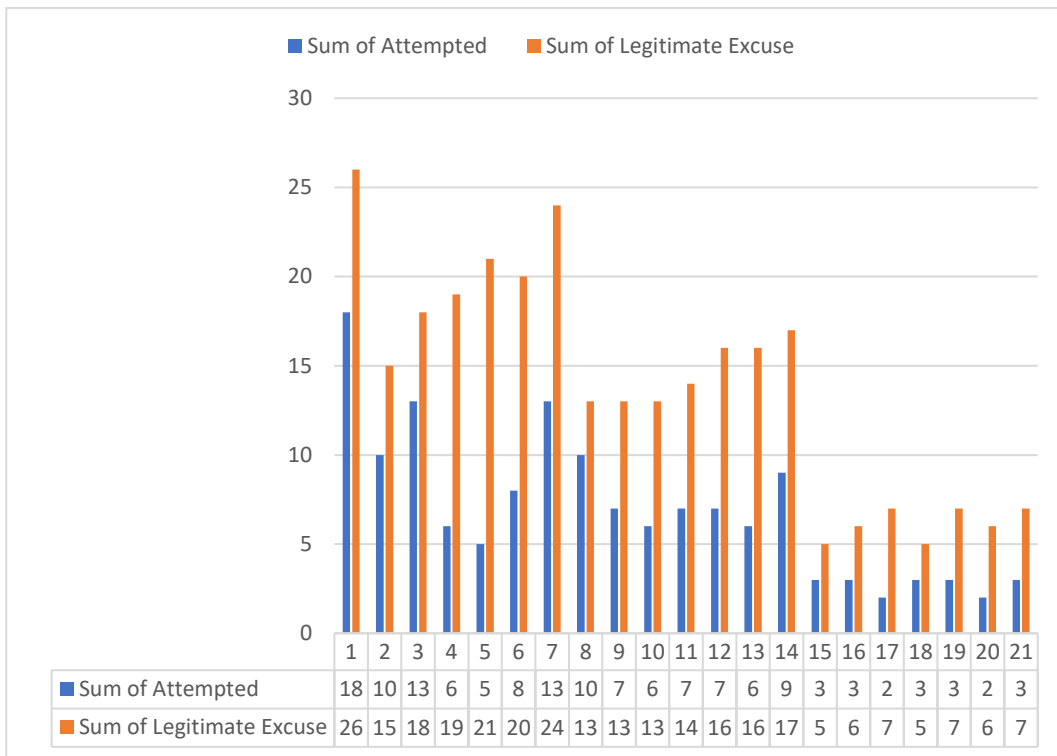
Description: the progression of the daily attempts with a legitimate excuse and all legitimate excuses over the course of three weeks.

Graph 5b legitimate Excuse and not attempted/ not attempted

Excuse and not attempted/ Not Attempted

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Not Attempted	44	49	56	70	75	72	73	82	90	91	91	93	94	93	110	112	115	111	114	115	114
Excuse & not attempted	0.0%	11.4	10.2	23.2	22.9	16.0	15.3	4.1%	7.3%	7.8%	7.7%	9.9%	10.8	8.5%	2.2%	2.7%	4.5%	1.7%	3.6%	3.5%	3.5%
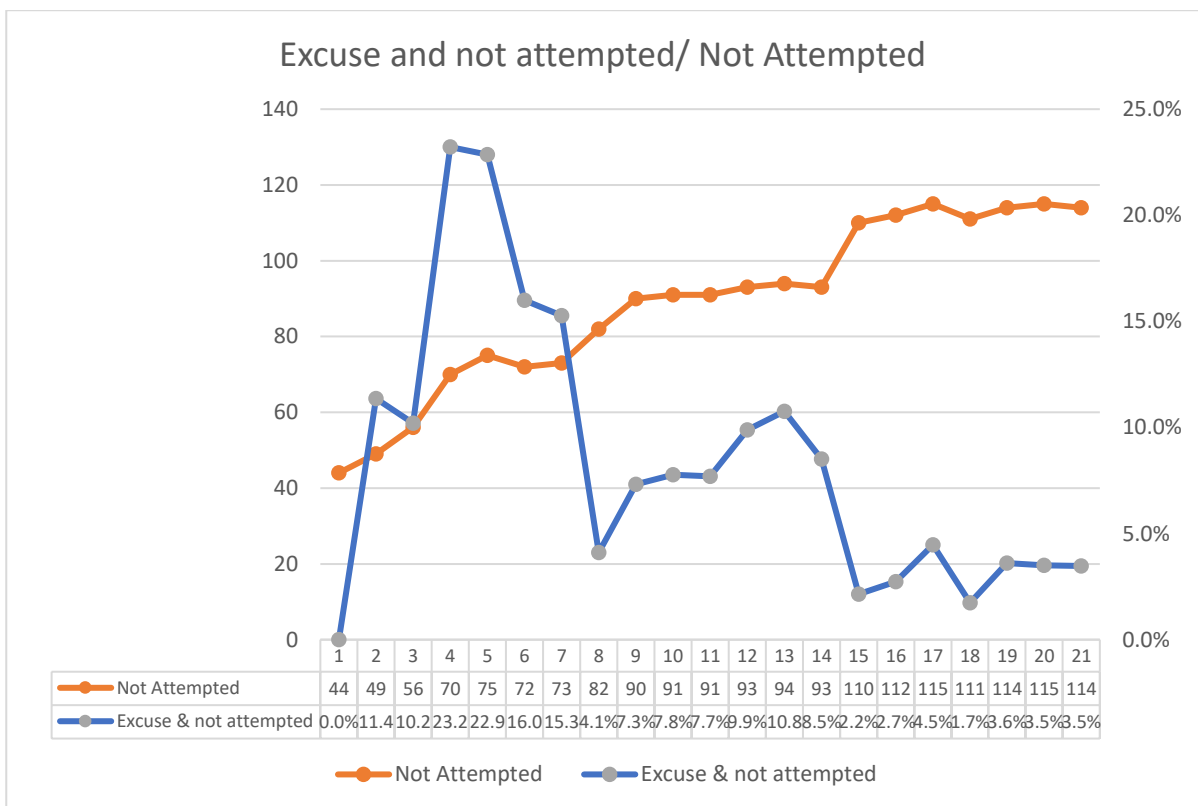
Description: the progression of all not attempted in relation to all not attempted

by participants with legitimate excuses over the course of three weeks.

Graph 6a Sickness and attempted

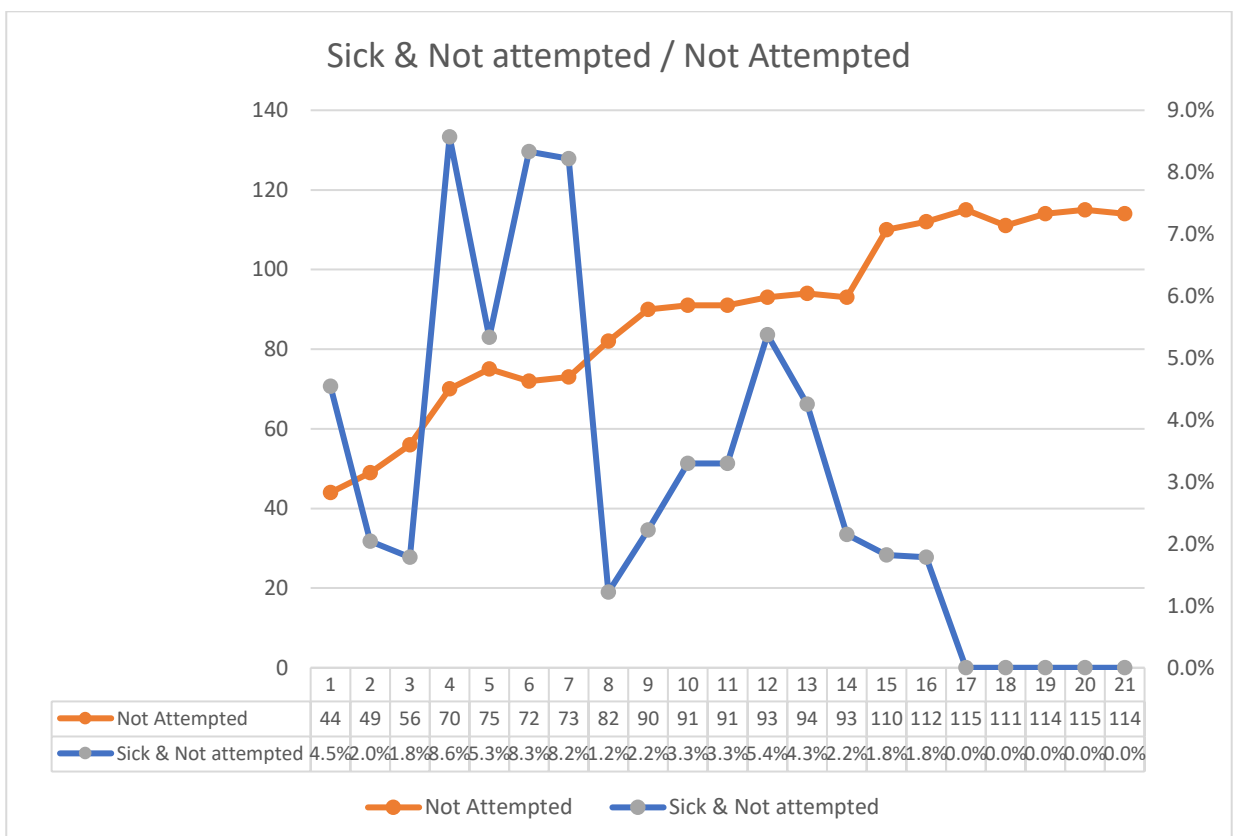|	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Sum of Attempted	0	1	1	2	2	4	6	1	0	1	1	1	1	1	0	0	0	0	0	0	0
Sum of Sickness	2	1	1	6	4	6	6	1	2	3	3	5	4	2	2	2	3	2	3	3	2
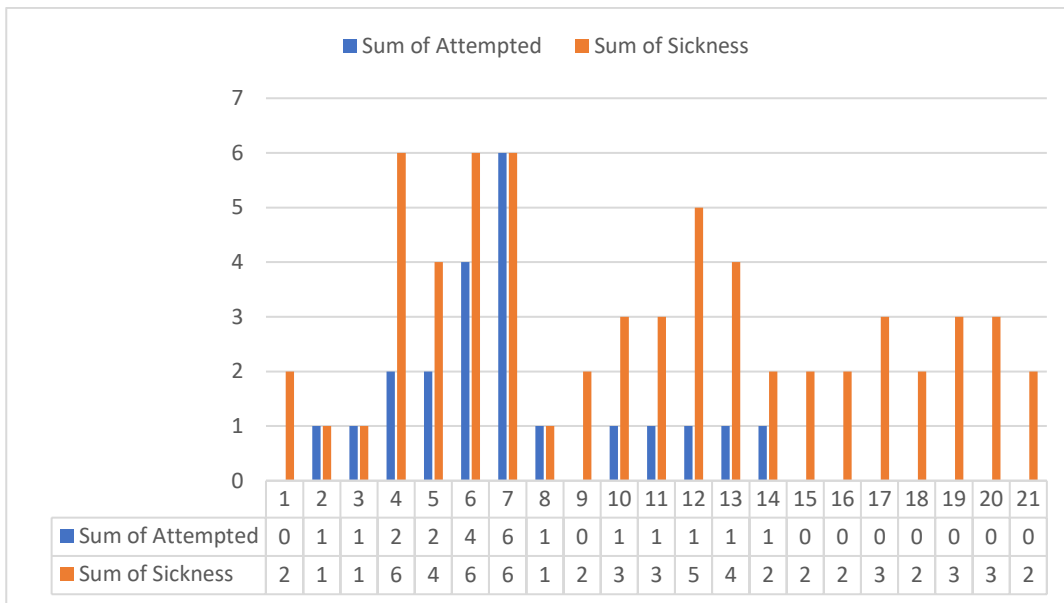
Description: the progression of the daily attempts with reported sickness and all reported sicknesses over the course of three weeks.

Graph 6b Sickness and not attempted/ not attempted

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Not Attempted	44	49	56	70	75	72	73	82	90	91	91	93	94	93	110	112	115	111	114	115	114
Sick & Not attempted	4.5%	2.0%	1.8%	8.6%	5.3%	8.3%	8.2%	1.2%	2.2%	3.3%	3.3%	5.4%	4.3%	2.2%	1.8%	1.8%	0.0%	0.0%	0.0%	0.0%	0.0%

Description: the progression of all not attempted by participants in relation to all not attempted

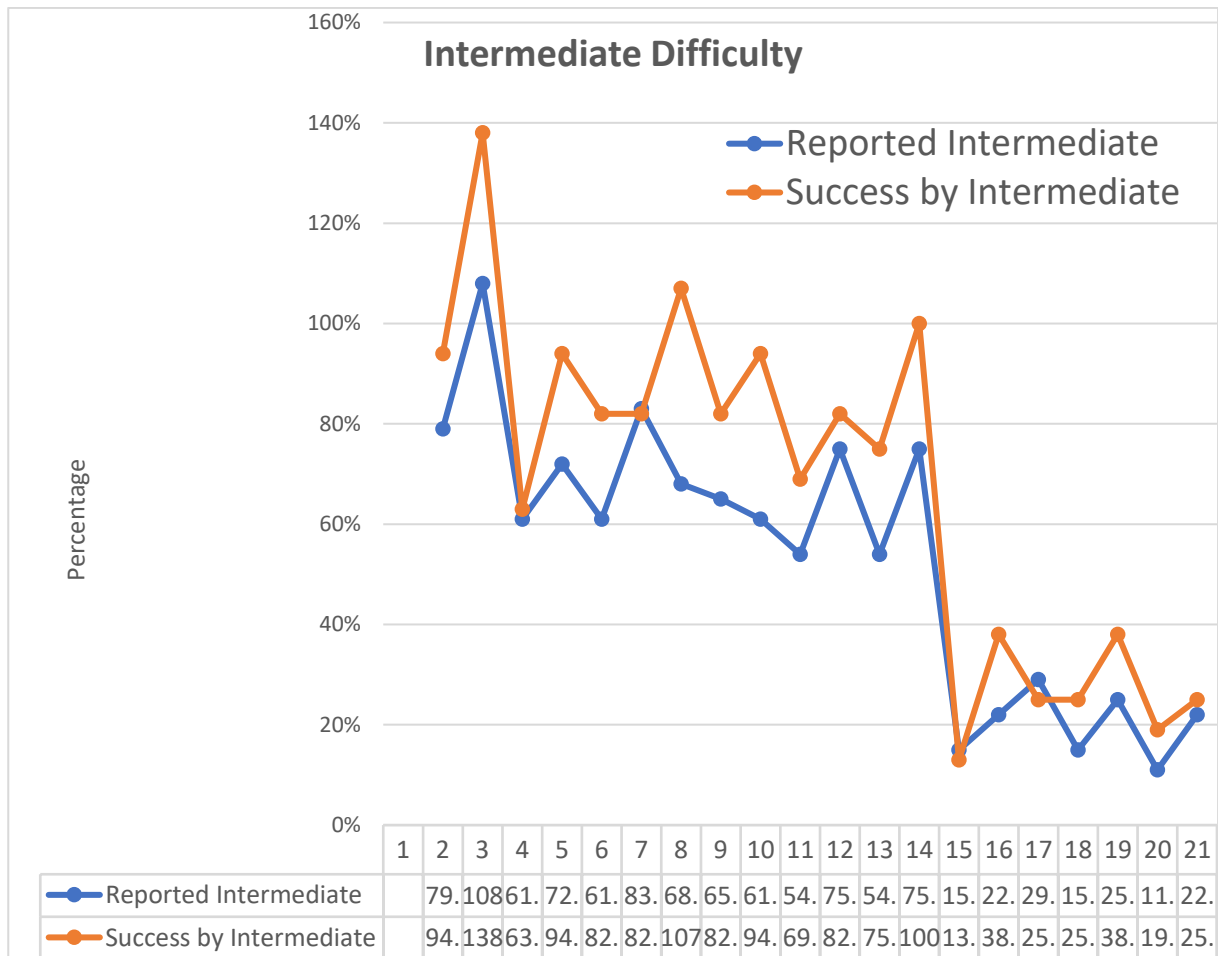by participants with reported sicknesses over the course of three weeks.

Graph 7a difficulty level easy

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Reported Easy		162	83.	59.	39.	83.	33.	62.	50.	50.	27.	15.	33.	33.	33.	24.	15.	33.	24.	30.	21.
Success by Easy		157	74.	70.	35.	79.	27.	74.	57.	61.	31.	18.	40.	40.	40.	31.	18.	35.	31.	31.	31.
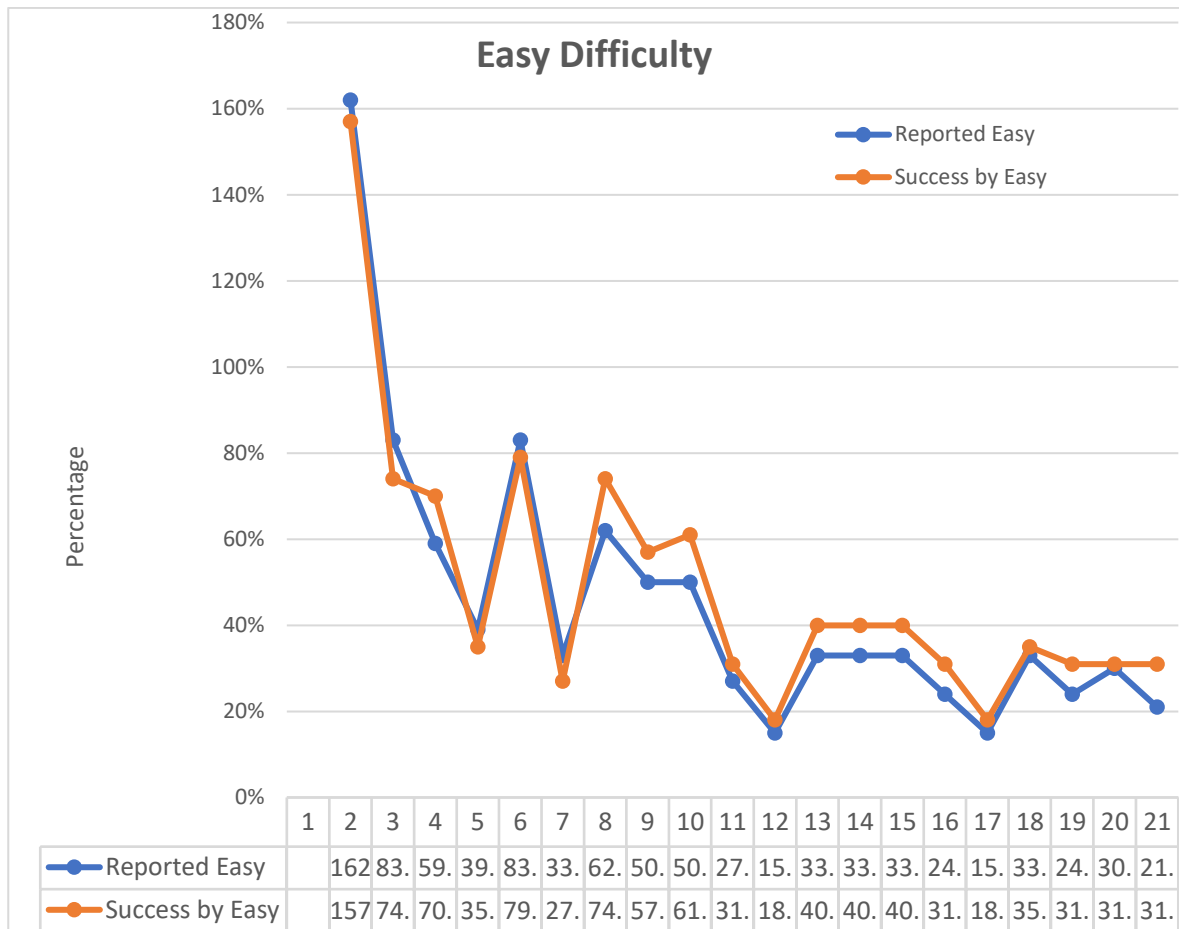
Description: the progression of participants reporting difficulty level easy and their success over the course of three weeks.

Graph 7b difficulty level intermediate

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Reported Intermediate		79.	108	61.	72.	61.	83.	68.	65.	61.	54.	75.	54.	75.	15.	22.	29.	15.	25.	11.	22.
Success by Intermediate		94.	138	63.	94.	82.	82.	107	82.	94.	69.	82.	75.	100	13.	38.	25.	25.	38.	19.	25.

Description: the progression of participants reporting difficulty level intermediate and their success over the course of three weeks.

Graph 7c difficulty level difficult

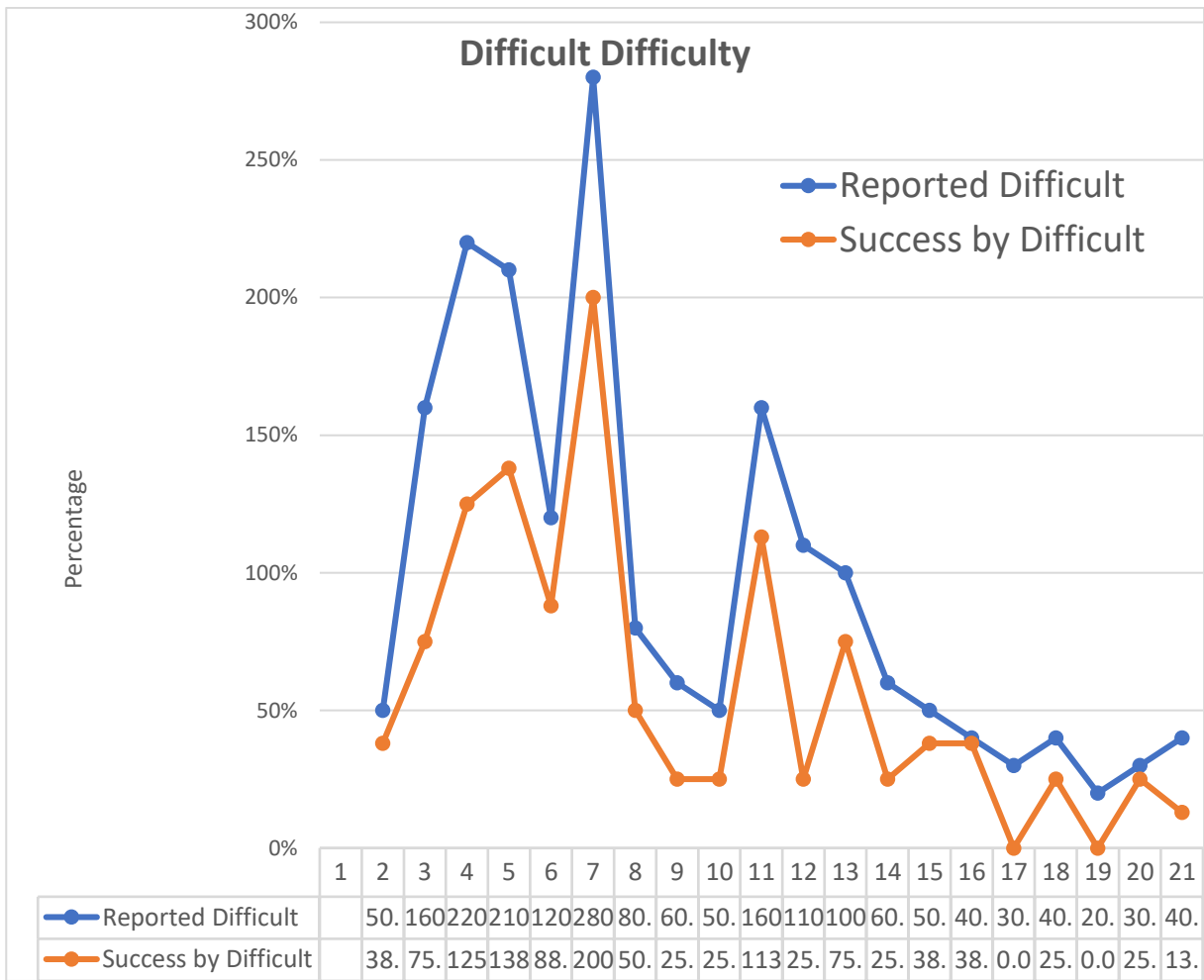Description: the progression of participants reporting difficulty level difficult and their success over the course of three weeks.