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Gamification of Self-Attachment as a Therapeutic Technique

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Submitted in partial fulfilment of the requirements for the MSc Degree in Computing Science of Imperial College London

September 2013

Acknowledgements

I would like to take this opportunity to express my gratitude and regards to my supervisor Professor Abbas Edalat for his guidance, monitoring and constant encouragement throughout the course of the project. I also would like to take this opportunity to thank all the volunteers who accepted to review the game. I am truly grateful for their cooperation during the period of my project. Lastly I would like to thank my family for their constant support and feedback without which this project would not have been possible.

Abstract

Mental illness is a vast problem facing our society. As many as one in four people develop at least one mental or neurological disorders in their lifetime. This problem can be rooted from a person having developed an insecure attachment type during childhood. The lack of a secure attachment can have a profound negative impact on the adult's interpersonal relationships, parenting abilities as well as becoming more prone to mental health disorders such as depression and anxiety. This project concerns the development of a therapeutic game based on the techniques behind Secure Self-Attachment Therapy. It allows users to effectively learn and apply the therapeutic techniques in hopes of helping them overcome psychological disorders. This project focuses on the development of a psychotherapy tool that reduces the need for interventions from therapists. The game is split into the 3 phases reflecting the process of the therapy. Phase 1 informs the player of the principles behind the therapy. Phase 2 is aimed to excite the player's emotion and this is implemented through a Memory Bank where the player is able to input and import media contents relating to their childhood. Phase 3 consists of an iterated game model of exercises aimed to form and strengthen neural networks associated with secure attachment. In this project an A.I. Guide was also developed in order to guide the player through the game. The A.I. Guide is modelled as intelligent agents with Q-Learning Algorithms emulating human learning behaviours. Two different models are developed and analysed in this project. The A.I. Guide is initialized with insecure avoidant attachment behaviours and through the iterated game process within the game, guides itself to secure attachment behaviours effectively simulating a player progressing through the game.

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Chapter 1

Introduction

1.1 Motivation

At some stage in life in both developing and developed countries, 1 in 4 people develop at least one mental or neurological disorder. In a study done by the World Health Organization [1] in 2001, approximately 450 million people suffer from mental illnesses globally. It can be seen that mental disorders are vast problems facing our society today. Hence many treatments and prevention programs have been developed in order to tackle this problem.

Traditional treatment methods are effective however it can be costly as the service requires trained therapists to devote substantial periods of time in treating one or a small group of subjects. Hence this service is not widely available hence alternative methods of treatment must be developed to allow more people to be treated. As a result, many computer based therapy programs have been developed in order to help subjects to treat themselves either with little or no interactions with a therapist. Along with the increasing accessibility to computers, these forms of computer based therapy programs would be an effective way to tackle the problem of mental diseases on a global scale.

1.2 Aim

This project concerns a developing form of therapy named "Secure Self-Attachment Therapy" developed by Professor Abbas Edalat from Imperial College London. This therapy is based on the theories and studies of Attachment Theory and it seeks to help subjects who have problems relating to an insecure attachment to their primary caregiver. Secure Self-Attachment Therapy seeks to help subjects form a secure attachment in order to remedy any negative consequences and problems rooting from a lack of a secure attachment during the subject's childhood.

The aim of this project is to develop a therapeutic game which uses the principles of Secure Self-Attachment Therapy as well as the principle studies and concepts of Attachment Theory.

Chapter 2

Background

2.1 The Human Brain

Secure Self-Attachment Therapy seeks to use scientific findings and developments from the study of the human brain and mind in order to make a practical therapy for people who suffer from attachment problems. In the scientific community, the study of the physical brain and the internal mind have been treated as separate. Biological sciences examine the structure of the brain and it involves the study of basic features of the brain and aims to work upwards in terms of complexity. On the other hand, Psychological sciences examine the workings of the internal minds and it involves the study of the complexity of individuals and aims to work downwards towards common features.

2.1.1 Physical Brain

From a theory developed in the 1970s by Paul MacLean named the "The Truine Brain"[2], the brain is thought of as composed of three components. Each of these components represent the different levels of sophistication developed throughout evolution. Although this model of the brain is over simplified, it is broadly accepted by neuroscientists. The first component is known as the "Reptilian Brain", which is the most basic component and acts as the core of the brain. The next component is named "The Limbic System", which processes emotions and memories. The last component is known as the "Cerebral Cortex" which is responsible for reasoning and the overall consciousness of the individual.

The Cerebral Cortex is further divided into four lobes. The Frontal Lobe is responsible for reasoning and attention. The Temporal Lobe is responsible for language, hearing and memory processing. The Parietal Lobe controls the body and movements. Lastly, the Occipital Lobe deals with visual processing.

The Limbic System contains the Amygdala, which is responsible for emotional understanding and fear. It also contains the Hippocampus, which is associated with the modulation of memory and emotion.

2.1.2 Brain Lateralization

Although a generalization, some functions in the brain are lateralized, meaning that they are predominantly processed by either the right or left side of the brain. In simplified terms, the left hand side of the brain is responsible for logic and language and the right hand side of the brain is responsible for creativity and emotion. The integration and communication between the two sides or hemispheres of the brain are essential in therapy. The reason is the Cerebral Cortex has

many connections to the Hippocampus, Amygdala and other Limbic System structures. Many psychological disorders, including depression and anxiety are associated with a sub standard or lower efficiencies in the communications between the brain's hemispheres. Secure Self-Attachment Therapy focuses on these principles and seeks to form and reinforce healthy and efficient neural connections between the two sides of the brain.

2.1.3 Mirror-Neurons

Neurons are cells within the brain that transmit electrical and chemical signals which stimulated. Along with synapses, which are the pathways between neurons to pass on signals, the brain creates a network of complex circuits. The brain consists of numerous types of neurons, however the specific type of neuron that Secure Self-Attachment Therapy is focused on is known as "Mirror-Neurons". Mirror-Neurons are a particular class of Visuomotor neurons, meaning that these neurons are stimulated and fire signals both when an action is performed or when an action performed is observed.[3]

Empathy, imitation and the understanding of other's actions are an important trait for primates, particularly for humans. Survivability of the human race has partially rooted from our ability to understand and empathize with the actions of others. Without this ability, social organizations would not be possible. However unlike most species, humans are able to learn through imitation and observation alone. This process is known as the "Mirror-Neuron Mechanism" and it is shown to be a fundamental role in terms of understanding, imitation and empathy.

The Mirror-Neurons were first discovered in monkey's Premotor Cortex. These neurons discharged and fired both when a monkey performs a particular action and when it observes another individual, monkey or human, performing a similar action. These neurons are essential to the formation of the bond between caregivers and infants as well as overall, learning and empathy. Secure Self-Attachment Therapy seeks to excite these neurons as an aid to the formation of healthy neural connections through the observation of actions that accompany healthy attachment behaviours between an infant and his or her primary caregiver.

2.2 Attachment Theory

Attachment Theory is a psychological model developed by John Bowlby and Mary Ainsworth. John Bowlby formulated the basic concepts of the theory and Mary Ainsworth developed the innovative methodologies to test Bowlby's theories empirically and also aided in the expansion of the theory itself.[4]

Attachment theory is the study of bonds between people and their lasting impacts on their psychological well being. The theory concerns the need for every infant to develop an emotionally supportive and dependant relationship with a primary caregiver, whom they become attached to.[5] The main focus of the theory is the type of attachment that the individual infant develops in relations to their caregiver. The attachment type the individual develops during childhood could have a lasting impact on the individual.

2.2.1 Attachment Types

In order to develop a healthy social and emotional behaviour, an infant should develop a secure attachment relationship with at least one caregiver.[6] Depending on the relationship between the infant and the caregiver, the infant could develop an insecure attachment relationship as well which could be problematic in later stages of life and could result in mental and behavioural problems. There are three types of insecure attachments; avoidant, anxious and disorganized attachment.[7]

The types of attachment can be observed on Table 2.1, where infants having each attachment types show different behavioural patterns.[8]

Without a secure attachment, the patterns which are formed during infancy have a big impact on future relationships. Attachment formed during childhood become relatively stable in adulthood and have been shown to impact romantic relationships, interpersonal attitudes and psychiatric systems. The lack of a secure attachment during an individual's childhood can have a profound negative impact on the adult's interpersonal relationships and parenting abilities, as well as the individual's contentment at work. [9]

	Low Avoidance	High Avoidance
Low Anxiety	Secure	Avoidant
High Anxiety	Anxious	Disorganized

Table 2.1: Four types of attachment sorted by anxiety and avoidance levels

2.2.2 Strange Situation

Attachment types of infants can be tested using the "Strange Situation" experiment devised by Mary Ainsworth during the 1970s.[10] This experiment was developed to investigate the attachment of an infant, between 12 to 18 months of age, to its mother and the effects of attachment types to behavioural patterns. The "Strange Situation" is a 20 minute miniature drama where depending on the interactions and behaviour patterns displayed by the infant during the experiment, the attachment type that the infant has developed can be evaluated.

The general procedure of the experiment is as follows. The infant and its mother are introduced to a controlled laboratory playroom, where they are later joined by an unfamiliar woman. The stranger then attempts to play with the infant and the mother is cued to leave the room. After a brief amount of time, the mother returns. Then both the stranger and mother leaves the room ensuring that the infant is completely alone. The stranger then returns and finally the mother as well.

In the "Strange Situation" experiment, an infant with a secure attachment will explore the playroom while the mother is in the vicinity. They will be distressed when the mother leaves the room and calmed and pleased when the mother returns. This is the most common attachment type and is present in cases where the caregiver, in this case the mother, responds to the infant consistently and is generally emotionally balanced. However, an infant with an insecure avoidant attachment would avoid or ignore their mothers and have a mixed behaviour regardless of who is in the room. Insecure avoidant attachment is developed when the caregiver is distant to the infant and encourages independence. An infant with an insecure anxious attachment will not explore the playroom and become very distressed when the mother leaves the room. Upon return, the infant will show resentment towards the mother and sometimes physically resisting contact to the mother. Insecure anxious attachment is developed when the caregiver is inconsistent with their behaviours resulting in the infant feeling a lack of a "secure base" to return to. Finally an infant with an insecure disorganized attachment will show dazed behaviours including being unresponsive, rocking back and forth and even self harm. Insecure disorganized attachment is developed when the infant is afraid of or is abused by the caregiver or at times when the caregiver suffers from severe attachment problems themselves.[11]

2.3 Neuroplasticity

Neuroplasticity is the ability of the human brain to undergo physical changes and development. It has been shown that the brain remains plastic throughout its lifetime and Secure Self-Attachment Therapy seeks to take advantage of the plasticity of the human brain.

Long-term Potentiation is defined as the long term strengthening of the synapse between two neurons caused by them being stimulated and fired synchronously. Secure Self-Attachment Therapy does not only seek the formation of healthy and efficient neural connections but also the strengthening of these connections through repeated excitement of these connections.

2.3.1 Earned Autonomy

Experiences of early childhood have shaping effects on the physical structure of the brain. However there can be considerable plasticity in attachment types throughout childhood, adolescence and adult life. Hence it is possible for an infant who has developed an insecure attachment to develop an autonomous healthy attachment as an adult and become capable of passing secure attachment behaviours to others. This process is known as "Earned Autonomy". However this process occurs during situations which can not be easily provoked. This includes secure loving romantic relationships or genuine conversion to religious beliefs.

2.3.2 Therapeutic Conditions

Neuroplasticity is the brain's ability to reorganize and change itself by forming new neural connections. In order to take advantage of neuroplasticity, it was suggested by Louis Cozolino that therapy needs to involve four main conditions. [12]

1. Establishment of a safe and trusting relationship
2. Mild to moderate levels of stress or anxiety
3. Excitement of an individual's emotion and cognition
4. The co-construction of new personal narratives

The first condition is for the subject to establish a safe and trusting relationship. This relationship in common therapy would be between the subject and therapist. However for Secure Self-Attachment Therapy where the subject undergoes the therapy alone, the therapeutic dyad of the therapist and subject is replaced by the dyad of the left hand side of the brain and the right hand side of the brain which represents the subjects adult and inner child respectively. The therapy relies on the subject's self trust which would fulfil the condition of having a safe and trusting relationship. This would be achieved easier as a degree of self trust is achievable for most people.

The second condition to provoke neuroplasticity is to seek for mild to moderate levels of stress and anxiety with the subject. This would case the subject to release neural growth hormones. In Secure Self-Attachment Therapy, in order to invoke a level of stress, the subject revisits his or her childhood memories.

The third condition is the excitement of both a subject's emotion and cognition. This helps the formation of new neural connections between the right and left hand side of the brain. Emotions can be excited through revisiting childhood memories and cognition can be excited through the understanding of the therapy's scientific backgrounds and concepts.

Lastly, the fourth condition is the co-construction of new personal narratives which can be achieved when a subject performs imaginative exercises involving the subject's memories. Secure Self-Attachment Therapy involves some exercises where the subject revisits past traumatic childhood events and by using the subject's imagination, intervenes with the adult self. This would be beneficial to the subject because with understanding the difference between accurate history and therapeutic co-constructed narratives, the subject's oppressive memories can be transformed into healing stories invoking the growth of healthy neural connections. However, it is important that the subject is informed of the scientific backgrounds of the therapy as many people would feel strong

hesitations performing exercises that involve actions such as playing with their memories with one's imaginations.

2.4 Psychotherapy

Psychotherapy[13] are therapeutic treatments that subjects use in order to improve their mental health. It seeks to explore an individual's or group's thoughts, feelings and behaviours for the purpose of obtaining a higher level of functioning or for problem solving. There are many forms of psychotherapy including Cognitive Behavioural Therapy and the newly developed Secure Self-Attachment Therapy.

2.4.1 Cognitive Behavioural Therapy

Cognitive Behavioural Therapy is a psychotherapy aimed to address dysfunctional emotions and negative behaviours and cognition. It involves to train the subject to understand thoughts, mood and actions through behaviours are interlinked. It seeks to aid the subject to recognize unhealthy thoughts and to break the habit of negative feedback loops where unhealthy thoughts affect and reinforce unhealthy moods and behaviours which actually originated from the unhealthy thoughts themselves. Cognitive Behavioural Therapy has become extremely popular as an alternative or supplement to pharmaceutical treatment. However this therapy is mainly concerned with the subject's current state and have little concern with the subject's past which is the main focus of the Secure Self-Attachment Therapy

2.4.2 Secure Self-Attachment Therapy

Secure Self-Attachment Therapy is used to help subjects form neural connections related to secure and healthy attachment. It uses principles from Attachment Theory and studies from neuroscience of the brain's workings, organizations and ability to change. Secure Self-Attachment Therapy seeks to break the problematic cycle of individuals who have unhealthy attachments end up reinforcing unhealthy attachment behaviours to others.

Secure Self-Attachment Therapy seeks to form the missing or weak neural connections between the left and right hand side of the subject's brain. The left hand side of the brain represents the logic and cognition part of the brain, whereas the right hand side represents the emotional and intuitive part of the brain. During therapy and through normal healthy attachment, the active right hand side of the brain will seek to establish a connection or attachment with the left hand side of the brain. The metaphor that is commonly used to describe this therapy and process is that the left hand side of the brain takes on the role of the caregiver and the right hand side of the brain takes the role of the subject's inner child. Hence for the therapy to take into effect, the adult caregiver must make a conscious, emotionally heightened decision to care for his or her inner child. Through mental processes, the neural patterns that represent a healthy attachment can be formed and gradually be strengthened.

Secure Self-Attachment Therapy is divided into three main steps.

1. Stimulate the logical and cognitive parts of the subject's brain
2. Establish a connection with the subject's inner child
3. Strengthen the neural connections for secure attachment behaviours

The first step is to allow the subject to understand the scientific principles and concepts that the therapy is built upon. This step aims to stimulate the subject's cognition and also invoke a level of arousal and stress which are both important to the formation of healthy attachment neural

connections. Also, with the subjects understanding the motives and reasoning behind the therapy, the subjects would experience less hesitation when exercises that seem pointless are asked to be carried out. So the first step of the therapy is to stimulate and convince the logical and cognitive part of the subject's brain to become invested to carry out the following steps.

The second step of the therapy is to excite and establish a connection or bond with the inner child of the subject. This is achieved by stimulating the right hand side of the subject's brain, which is responsible for emotion and intuition. This connection stems from the subject's emotional bond with themselves as a small child. This can be evoked by exploring the subject's past and childhood through media or imaginative exercises. Through this process, the therapy seeks to emulate the strong attachment feelings that entails from falling in love with one's child or partner. This step invokes the emotional portion of the brain represented by the subject's inner child, which is vital to the formation of healthy attachment neural connections. The subject should think about their inner child and be compelled to make a sincere promise and commitment to look after and care for this child.

Finally, the third step revolves around exercises aimed to connect the adult self to his or her inner child. These exercises are used to form and strengthen the neural connections that emulate a healthy and secure attachment an infant develops towards a caregiver. These exercises are split into two categories; the first set of exercises seeks to help the subject deal with negative emotions and the second set of exercises help the subject produce positive emotions. The positive emotions will in turn keep the emotional bond with the inner child on going, resulting in the strengthening of the healthy attachment neural connections and eventually overshadowing the insecure and unhealthy ones.

Effective Exercises

For subjects who have tried this therapy, the feedbacks show that exercises revolving around songs and music are useful and effective in the treatment. These exercises include constructing a play-list consisting of childhood songs or any other songs that reminds the subject of their childhood. Then the subject would be able to listen to the play-list regularly. Another exercise would prompt the subject to listen and learn the lyrics to a song that invokes happiness and strong emotions and use it as a tool to interact with their inner child. This includes singing out loud whenever the subject is feeling distressed. The aim of these exercises is to provoke the subject to remember the commitment they made to their inner child to take care of them as well as to excite the emotional side of the subject's brain.

Another set of exercises that is proven to be effective are exercises involving playing and mirroring. Playing between a caregiver and their infant is important in the formation of a bond between them. Meeting ones gaze and imitating the other's behaviours can invoke happiness and joy in each other. Hence, replicating these behaviours are essential in Secure Self-Attachment Therapy. These exercises include standing in front of a mirror and singing a childhood song while gazing into one's eyes. Dancing in front of a mirror or imagining playing with their inner child has also shown to be effective emotional connection strengthening exercises.

For subjects who lack a secure attachment with their parents may have had some traumatic experiences as an infant. As part of the Secure Self-Attachment Therapy, the subject could revisit these experiences. However during this exercise, the subject remembers the traumatic event however as if they are watching the event from the outside. The exercise then instructs the subject imagining themselves entering the scene as an adult and removing the distressed child from the scene. The subject is required to actively think about the commitment they made towards that child while performing the exercise. The exercise allows the subject to create a new narrative out of the traumatic memory and form new connections that represent caring attention that is associated with this new narrative. This results in the formation of new, healthy neural connections. This exercise is aimed to deal with subjects that have experienced childhood traumas.

In order to deal with difficult present situations, including stressful situations in a subject's work or personal life. A subject may experience strong emotions relating to rejection, fear and anger. The subject can then perform another exercise which deals with these situations. The subject imagines a situation or even where the inner child whom they have made a sincere and caring commitment with is overwhelmed with the same strong emotions. This situation can be based on a real memory or purely imaginative. The exercise then prompts the adult self to enter the scene and comfort the distressed child. Through this mental exercise, the subject learns the process to comfort the child and subsequently learns to deal and cope with these strong emotions.

2.5 Modelling of Secure Self-Attachment Therapy

Modelling of the brain and the psychotherapy in general is important to the understanding of the workings of the mind. It allows us to take a quantitative and scientific approach to developing effective and repeatable treatments as well as allowing us to obtain more accurate models of our brain.

2.5.1 Hopfield Neural Network Model

There have been attempts to model the workings of the human brain using computers. The reason is that with an accurate model, we can have a deeper understanding of how the mind works and also create more 'intelligent' artificial intelligence. However, even with the increasing computing power and the complexity of artificial neural networks, there is still a vast gap in modelling the complexity of the human brain.

However, artificial neural networks have shown how connections and pathways between neurons in small networks are formed. In 1982, John Hopfield developed an artificial neural network model which had the ability to store and retrieve patterns. The network is able to retrieve the full pattern or memory from patterns from partial or corrupted data. Although a simplification of the brain, the Hopfield model has been very important and influential on neural network developments. [14]

2.5.2 Game Theory

Game theory[15] is a mathematical model of conflict and cooperation of decision makers given a limited action set. The common representation of the model is through a game matrix which shows the players, strategies, and pay-off for each action. Without knowledge of the other player's move, given an action choice, a player will choose the action that returns the highest pay-off.

Nash Equilibrium and Pareto Optimal

Within a game scenario, the individual pay-off of the actions determine the strategy that a player adopts. Nash Equilibrium[16] is the situation in a non-cooperative game where each player assumes to know the equilibrium strategy and no player has anything to gain by changing action choices or strategies.

Pareto Optimal[17] defines as the strategy where there does not exist an alternate strategy where an individual's pay-off is better off without making another player's pay-off worse. Hence it is the optimum strategy where both player collectively obtains the most gain or reward.

Secure Self-Attachment Therapy

In order to represent the attachment interactions between an infant and their caregiver or parent, a game theoretic description[18] using a reinforcement learning based framework is developed. This game theory models the adaptive model of a child to parent relationship. Through targeted reinforcements, a child with initially an insecure avoidant attachment with their caregiver is shown to lead into forming attachment behaviours relating to secure attachments. This model relies on the parent's pay-off matrix evolving over time. Ideally through a reinforcement learning based framework, the initial pay-off matrix of the relationship between an insecure avoidant child with their parent shown in Figure 2.1 would eventually evolve into the pay-off matrix of both a secure and insecure avoidant child to parent relationship pay-off matrix, shown in Figure 2.2. For both of the pay-off matrix, the child's pay-off is given first for each action.

		Parent	
		Attend	Ignore
Child	Go	4, 2	2, 3
	Don't Go	3, 1	**3, 4**

Figure 2.1: A Type-IIA game with an avoidant Nash equilibrium

		Parent	
		Attend	Ignore
Child	Go	**4, 4**	2, 2
	Don't Go	3, 1	**3, 3**

Figure 2.2: A Type-IIB2a game with secure and avoidant Nash equilibrium

The Type-IIA game shown in Figure 2.1 represents a game where the insecure avoidant attachment style is reflected. This game is a representation where the child's stress levels will increase when they seek for attention and the parent chooses to ignore the child. This is due to the greater pay-off of the parent to ignore the child given that the child has chosen to 'Go' to the parent, or seek for attention. Hence given that the parent's 'Ignore' strategy is more dominant, the child is always better off by choosing the "Don't Go" strategy to maximize its reward. This game matrix shows a representation of an insecure avoidant behaviour and consist only of a single Nash Equilibrium strategy at "Don't Go, Ignore".

The Type-IIB2a game shown in Figure 2.2 represents a game where both a secure and insecure avoidant attachment style are reflected. The game is a representation where the child's stress level will increase when they seek for attention and the parent then chooses to ignore the child. However in this pay-off matrix, the parent would prefer to attend to the child if it chooses to seek for attention as the parent would gain a higher reward. This game matrix consists of two Nash Equilibriums at "Go, Attend" and "Don't Go, Ignore". The equilibriums represent a secure attachment style and an insecure avoidant attachment style respectively.

The aim of an iterative game is to allow for a change in attachment style. This is based on the study that radical changes in a way a parent interacts with their child can result in a change in the attachment style. With games that have two Nash Equilibriums such as in the Type-IIB2a game shown in Figure 2.2, the attachment style can be transitioned from an insecure avoidant to a secure attachment style by just shifting from one equilibrium to another. Once this transition has been achieved, neither the child or parent would have any incentive to deviate from this equilibrium strategy since it is the optimal choice for every iteration. Hence all that is required is for the parent to realise that there is a more efficient equilibrium that exists and for the parent to direct all interactions with their child towards this equilibrium. Through this process , an insecure avoidant attachment style can transition into a secure attachment style.

In this case, we assume that the child uses the initial pay-off matrix to determine its strategy since

the child is unaware of any changes to the structure of the game being played. We also assume that the child will be playing a reactive strategy meaning that they will pick their move for each iteration based on the analysis of the pattern of play by the parent. Hence the child is assumed to not be guiding the interaction patterns to a new equilibrium. With these assumptions, the parent's pay-off matrix must change in order for a new equilibrium relating to a secure attachment style to emerge. This means that the parent must deliberately change the value they place on individual game outcomes. This is achieved iteratively with a reinforcement rule where actions that lead to a secure attachment style equilibrium are rewarded.

For this Secure Self-Attachment Therapy game, the right hand side of the brain represents the inner-child and the left hand side of the brain represents the adult or parent. Hence it is important for the subject to be aware of and understand the scientific principals of the therapy. The left hand side of the brain, which governs logic and cognition, must be aware of the structure of the game so that the subject can choose actions and strategies that lead the equilibrium to a secure attachment style.

2.6 Iterative Game Model

This section concerns the modelling of changes in attachment styles through an iterative game. In games where there are multiple Nash Equilibriums, a shift of attachment style from insecure to secure can be achieved by shift from one equilibrium to another. In the case of Figure 2.2, there are two Nash Equilibriums. A shift from "Don't Go, Ignore" to "Go, Attend" would cause a transition of attachment style from insecure avoidant to secure. This could be brought about by the parent's realisation that a more optimum equilibrium exists and for them to direct their interactions with the child towards this equilibrium. Once the transition is achieved, both the child and parent would not benefit from changing strategies since "Go, Attend" would be a Pareto Optimal Nash Equilibrium, so both individuals would maintain the same strategies.

For games that only have one Nash Equilibrium, before an attachment transition can occur another Nash Equilibrium must be created. For a new Nash Equilibrium to emerge, it is important for the parent to not only change their behaviour but also change their pay-off matrix, or the value they give to each action. This means that their expected outcomes of their interactions with the child must be changed as well. This change can be achieved by using pay-off reinforcement and behavioural learning. Through this process, a Nash Equilibrium relating to a secure attachment style will emerge. In this section, the model of transitioning from a game where there is initially just an insecure avoidant Nash Equilibrium (Figure 2.1) to both secure and insecure avoidant Nash Equilibriums (Figure 2.2) is explored.

2.6.1 Markov Decision Process

Markov Decision Process is a mathematical framework for modelling decision making.[19] It seeks to model the decision process where the outcomes are partially random and partially in control of the decision maker.

A Markov Decision Process consists of a finite set of states S representing decisions made over time. At each discrete step in time, the system is in some state $s \in S$. Each state consists of a finite action set A where the decision maker has a choice of actions to choose from. For each decision, the decision maker chooses a single action $a \in A$. This action can be selected through a probabilistic state transition function $P_a(s, s')$. The chosen action causes the Markov Decision Process to transition to a new state $s' \in S$. On transitioning to this new state s', the decision maker receives the corresponding reward $R_a(s, s')$. The decision maker would then behave so as to maximize its probabilistic rewards. Therefore the characteristic of the decision maker brought

about by the Markov Decision Process depends primarily on the behavioural policy that governs which action it chooses at each state.

2.7 Intelligent Agent

This section focuses on the modelling and implementation of a behavioural policy representing parent to child interactions. Given a iterative game scenario, we will examine the how a Markov Decision Process agent, through Q-leaning and Reinforcement Learning can model a transition of initially insecure avoidant attachment behaviours to that of secure attachment behaviours. In this project, the modelling of Intelligent Agents allows for the development of better methodologies, procedures and game mechanics in order to maximize the effectiveness of the therapeutic aspect of the Secure Self-Attachment Therapy. Also, the Intelligent Agents are used as a guide for players, allowing them to progress through the game at a pace that is modelled on human learning behaviours.

2.7.1 Reinforcement Learning

As mentioned before, in order for a new Nash Equilibrium relating to secure attachment behaviours to emerge, the parent's pay-off matrix must change over the course of the iterated game. This means that the parent must change the values they place on the game outcomes, so that they eventually choose actions that represent secure attachment behaviours. Reinforcement Learning[20] is a model for the learning process of the parent. Through reinforcement of certain game outcomes, the parent to child interaction gradually transitions into a stable secure attachment relationship.

$$\begin{bmatrix} t & u \\ v & w \end{bmatrix}$$

Figure 2.3: Parent's pay-off matrix

Figure 2.3 represents the parent's pay-off matrix for the iterated game. At the end of each round, both the parent and child picks an action (a_p, a_c). For the parent either 'Attend' or Ignore and for the child either 'Go' or "Don't Go". The pay-off matrix represents the value the individual places on each game outcome. In Figure 2.3, t represents the pay-off for the game outcome "Attend, go", u is the pay-off for "Ignore, Go", v is for "Attend, Don't Go" and finally w corresponds to the pay-off for "Ignore, Don't Go".

For Reinforcement Learning[21], only desirable game outcomes are reinforced. Once the action pair for a desirable outcome has been chosen (a_p, a_c), the pay-off for that action in the parent's pay-off matrix is reinforced. These desirable action pairs are grouped into a set η. In order to achieve a secure attachment pattern, both the parent and child must transition to a stable pattern of choosing the action pair "Attend, Go". This means that "Attend, Go" should be reinforced in the parent. However another action pair can be reinforced to encourage secure attachment interactions. The action pair "Attend, Don't Go" should also be reinforced. The reason is with the parent choosing 'Attend', the child would be more encouraged to choose 'Go' in the following rounds. Hence the set of action pairs that would be reinforced for the parent is given below.

$$\eta = (Attend, Go), (Attend, Don'tGo) \tag{2.1}$$

For the reinforcement, the model is to use a reinforcement parameter defined by r, and that $r > 1$. For a round where the chosen action pair $(a_p, a_c) \in \eta$, the particular pay-off value in the parent's pay-off matrix is increased or reinforced by this factor r. At any state, the reinforced pay-off matrix of the parent will be as shown on Figure 2.4 where n_t represents the number of

times "Attend, Go" was the game outcome and n_v represents the count of "Attend, Don't Go". With these reinforcements, the parent will increase their value of choosing 'Attend' throughout the iterated game which would encourage the child to choose 'Go'. This would cause a new Nash Equilibrium relating to secure attachment behaviours to emerge and eventually the parent and child will form a stable secure attachment interaction where "Attend, Go" is the Pareto Optimal Nash Equilibrium.

$$\begin{bmatrix} tr^{n_t} & u \\ vr^{n_v} & w \end{bmatrix}$$

Figure 2.4: Parent's pay-off matrix with Reinforcement Learning

2.7.2 Q-learning

Q-Learning[22] is a reinforcement machine learning technique. It can be used to find the optimal action to choose given a finite Markov Decision Process. Although it is not a complete and accurate representation of the human brain and its learning process, it was shown by Erev and Roth [23] that reinforcement learning techniques can be used to explain and predict people's behaviours in a game environment.

The Q-Learning Algorithm seeks the optimal action choice for each discrete state of the Markov Decision Process. It is able to solve Markov Decision Processes without the need of knowing the state transition probabilities. The main concept behind the algorithm is having an action-value function that returns the expected utility of choosing a particular action in a given state. Once this action-value function is computed, the algorithm then uses a behavioural policy to select an action based on its value. Before exploring this algorithm, it is important to understand state transitions and ordinal pay-off matrices.

State Transitions and Ordinal Matrices

In this evolving iterative game scenario, it is not only important that the parent changes the values within its pay-off matrix but also the parent must undergo transitions in the strategy behind choosing actions. This change in strategy is brought about by the change in the relations between the pay-off values for each action. An ordinal matrix is a representation of the the player's state and the order of value they place on the game outcomes. In this case, for a transition from an insecure avoidant attachment interaction to a secure attachment interaction, the ordinal matrix would have to change resulting in a state transition as shown on Figure 2.5. For every ordinal matrix change or state transition, the player or in this case the parent would have to re-evaluate his or her strategy and change it to adapt to the new action-values.

$$\begin{bmatrix} 2 & 3 \\ 1 & 4 \end{bmatrix} \Rightarrow \begin{bmatrix} 4 & 3 \\ 1 & 2 \end{bmatrix}$$

Figure 2.5: State Transition from Insecure Avoidant to Secure Attachment Behaviour

The ordinal matrix, or state represents the relative value that the parent places over game outcomes. In this case there are 41 possible states. The breakdown of all possible states is given as follows. For cases that $t \neq u \neq v \neq w$, there are 4! states for the permutation of all strict ordinal pay-off matrices. For non strict ordinal pay-off matrices with two equal elements for example $t \neq u \neq v = w$, there are 4!/2! possible states. Similarly for cases with three equal elements for example $t \neq u = v = w$, there are 4!/3! possible states. Finally there is an additional state, or 4!/4! state for the scenario where all the pay-offs are equal $t = u = v = w$. This gives a total of 41 possible ordinal states.

Q-Learning Algorithm

The Q-Learning Algorithm seeks to learn the optimal action choice for each state of the Markov Decision Process. The algorithm consists of a function called the "Q Function" which calculates the quality or expected utility of a particular action pair. The Q Function is defined below.

$$Q : S \times A \to \mathbb{R} \tag{2.2}$$

The Q Function calculates the Q values of each action choice. The Q values are an estimate of the reward the player will receive from choosing the particular action. Hence the Q values can be observed as representing the quality associated with each action that is available to the player at a given state of the Markov Decision Process. The Q values are initialized to the the initial pay-off values of an insecure avoidant attachment behaviour pay-off matrix. The Q values are then updated at the end of each iteration or round when a decision is made resulting in a change of state in the Markov Decision Process. Depending on the reward the player receives after each round, the player re-evaluates the quality of each action through an update rule. This rule represents the learning process that the player undergoes throughout the iterated game. The update rule is given below.

$$Q(s,a) \leftarrow Q(s,a) + \ell[R_a(s,s') + \delta \text{max}Q(s',a') - Q(s,a)] \tag{2.3}$$

$Q(s,a)$ represents the Q value for a given action a at state s, $\text{max}Q(s',a')$ is the maximum Q value of the new state s' and $R_a(s,s')$ is the reward or pay-off given to the player after a decision of an action and a transition to a new state $s \to s'$ in the Markov Decision Process. The parameters for this update rule and Q-Learning Algorithm are the discount factor δ and the learning rate ℓ, where $0 \leq \delta < 1$ and $0 < \ell \leq 1$.

The discount factor δ represents the value players place on immediate and future rewards. It determines how a player reflects on the relation of immediate rewards opposed to future rewards. A discount factor of 0 signifies that the player only values current rewards and a discount factor of 1 signifies that the player values long term rewards.

$$\ell_1, \ell_2, \ell_3 ... \text{ such that } \sum_{i=1}^{\infty} \ell_i = \infty \text{ and } \sum_{i=1}^{\infty} \ell_i^2 < \infty \tag{2.4}$$

The learning rate ℓ states the rate at which new information overwrites old information. It determines the extent at which the player learns new information. This means that a learning rate approaching 0 would signify the player not being able to learn new information whereas a learning rate of 1 signifies that any new information overwrites the old information during the update process. Watkins and Dayan [24] showed that if the learning rate ℓ decreases in succession as shown on Equation (2.4), then the Q-values will eventually converge on the optimal behavioural policy given that each action pair in a given state (s,a) is picked an infinite amount of times. The rule behind this decreasing learning rate is given below.

$$\ell(s,a) = \frac{1}{n(s,a)} \tag{2.5}$$

In Equation (2.5), the $\ell(s,a)$ represents the learning rate of an action a in a given state s and the $n(s,a)$ represents the number of times the action has been chosen in a given state. The learning rate is initialized at 1, $\ell = 1$, and decreases with each subsequent decision of an action. Hence the more times an action has been picked, the player learns less from each iteration. Also given an ordinal change, or state transition, the player re-evaluates its values on each action meaning that the learning rate for all actions are re-initialized to 1 to allow for new information to be

learnt. For this learning model to converge to an optimal behavioural policy, all actions must be explored to exhaust the action choices.[25] Hence it is important to implement a behavioural policy based on probability that not only prefers higher Q valued actions but also allows for action exploration.

2.7.3 Exploration Behavioural Policy

A behavioural policy determines which action is chosen by the player. An optimum behavioural policy would ideally pick the action which has the highest expected rewards for each round. However Q-Learning depends on each actions in the state space to be picked in order learn new information. If the optimal behavioural policy was used, actions associated with non-optimal Q values would never be picked, hence the player would not learn any new information and only pick actions that seem to have the highest rewards. In order to solve this problem, probability is introduced in the action selection process. This is achieved by having actions with higher rewards or Q values to be prioritized but also allow the chance for lower Q valued actions to be chosen as well. This allows for actions associated with non-optimal Q values to be played and allows for greater exploration of the action state space in the Markov Decision Process. For the implementation, a Boltzmann action selection rule is used. At a given state s, the probability that action a_i is selected is given below in Equation 2.6.

$$P(a_i|s) = \frac{k^{Q(s,a_i)}}{\sum_i k^{Q(s,a_i)}} \tag{2.6}$$

The exploration parameter k is defined to be $k > 1$. It indicates level of exploration that the player behaves in. As k increases, the probability of selecting actions associated with low rewards or Q values becomes smaller. In this project, the exploration parameter of $k = 2$ is used and the effects of changing this parameter are not explored.

2.7.4 Implementation

In this project, two different implementations of Intelligent Agents based on the Iterated Game Model is examined. Both of the implementations provide a parent and child model which transitions initially from an insecure avoidant attachment interaction to that of a secure attachment interaction. In this section, the two implementations are described.

David Cittern Implementation

This implementation is based on the works of David Cittern and Professor Abbas Edalat. [26] In this implementation, the parent is modelled with a Q-learning algorithm with reinforcement learning where the set of reinforced actions for the parents are the actions that promote secure attachment behaviours given on Equation 2.1.

In Cittern's implementation, the child is believed to be unaware of any changes to the structure of the iterated game and will therefore have a strategy according to its initial pay-off matrix. It is also assumed that the child will be using a strategy with reactive properties meaning that its action chosen is based on their analysis of the parent's pattern of play. The Best Response to Last Move (BRTLM) strategy is used for the implementation of the child. The child assumes that the parent will play the same move that they played on the previous round and picks the move corresponding to the highest pay-off based on this information.

To conclude, Cittern's implementation is based on the concept that the parent is the only driving force behind the change in the interaction and state of the game. So in order for there to be a new

stable Nash Equilibrium relating to secure attachment interactions to emerge, the parent would have to deliberately guide the interaction patterns with the child.

Cai Zhou Implementation

This implementation is based on the works of Cai Zhou [27]. In this implementation, multi-agent Q-Learning is used. This means that both the parent and child are modelled with a Q-Learning algorithm. This means that both agents have the learning ability to make choices to adapt to each other.

$$\eta = (Attend, Go), (Ignore, Go) \tag{2.7}$$

In this implementation, the parent model is the same of that in Cittern's implementation. The child is modelled with the same Q-Learning Algorithm. However, the difference for the child is that the reinforcement rule should encourage actions that promote secure attachment interactions, in this case it would be 'Go' as shown in Equation 2.7. This means that the reinforced pay-off matrix would differ as well and it is given in Figure 2.6. The elements correspond to the same game outcome as the iterated game model in Figures 2.1 and 2.2. As it can be observed that only choices in the payoff matrix of the child that involves choosing 'Go' is reinforced.

$$\begin{bmatrix} os^{n_o} & ps^{n_p} \\ q & y \end{bmatrix}$$

Figure 2.6: Child's pay-off matrix with Reinforcement Learning

To conclude, Zhou's implementation is based on the concept that both the parent and child have the ability to make decisions so as to both guide the interactions towards one that resembles a secure attachment. It was shown that the multi-agent Q-Learning allowed for both parent and child to transition to a stable secure attachment interaction quicker than the single-agent Q-Learning implemented by Cittern.

2.8 Computerized Psychotherapy

With the widespread of mental illnesses around the world, it is important to have easy access to treatments or therapy. Since many psychotherapy methodologies rely on a timely relationship between a subject and a trained psychotherapist, accessibility is becoming more of a concern in the hopes of tackling mental illness. Along with the increasingly popularity and decreasing price of the personal computer, there have been many developments in computerized psychotherapies or programs that are based on psychotherapeutic practices. The therapies that have proven to be more effective after automation would be directive forms of therapy where the reliance of a bond between a therapist and the subject is not a necessity. For this reason, computerized psychotherapy based on Cognitive Behavioural Therapy has been proven to be most successful so far in tackling mental illness from a computer program. In this section, some examples of such computerized psychotherapy are explored and discussed.

2.8.1 Beating the Blues

Beating the Blues[28] is a computer program that offers sessions that players go through in order to tackle problems such as anxiety, depression, stress or other mental issues. It is based on Cognitive Behavioural Therapy and is currently available on the NHS in the United Kingdom depending on whether the patient's Primary Care Trust has decided to fund the treatment. It consists of 8 sessions

that focuses on Cognitive Behavioural Therapy techniques. Each session takes approximately 50 minutes to complete and the patient is recommended to go through a session per week and also perform techniques outside of session time.

Figure 2.7: Screen-shot of Session 1 in Beating the Blues

In Beating the Blues, the computer program takes the role of the therapist as part of the psychotherapy process. Directions, information and responses are pre-recorded by an actress. The recorded messages seek to emulate the calming and empathic feedback and conversation that relates to a trained therapist but computer limitations mean that it has to be run from a script. Hence, through feedback and direct evaluation of Beating the Blues, the pre-recorded messages gives off the impression that it does not care about the individual and accentuates the void of not having an intelligent agent or trained therapist to empathize with. Also, it was found that the interactions between the user and the program is very minimal. Apart from recording the stress level felt by the user, most of the inputs is for the progression of the program itself. These limitations show the flaws in having a computer program based on therapies that mainly rely on a bond between a subject and their therapist.

2.8.2 SPARX

SPARX[29] is a computer game based on Cognitive Behavioural Therapy techniques that is aimed at adolescents suffering from depression and anxiety. Unlike Beating the Blues, SPARX is designed as a third person interactive game which therapeutic information and techniques embedded within the content and the game-play of the program itself. SPARX divides the steps of Cognitive Behavioural Therapy into 'provinces' within the game. The character travels to each of these provinces in sequence and through events that occur within each province, the player learns how to deal with different situations and emotions.

In this project, exposure to this program allows for direct evaluation of the game SPARX. Although the graphics of the game is familiar in the sense of an adventure game, the game-based techniques that introduce Cognitive Behavioural Therapy techniques and information seemed limited and at times forced upon. However some techniques were observed especially puzzles that involve having to talk to the surrounding characters to learn the necessary therapy techniques in order to progress through the game. For example to open a treasure chest, the correct motivational phrase must

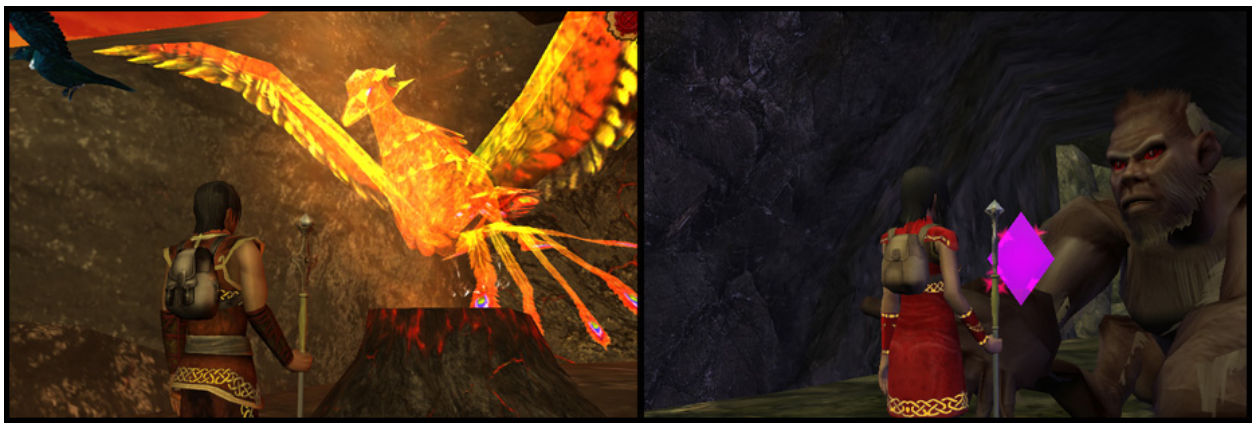


Figure 2.8: Screen-shots of SPARX game-play

be selected and dictated. Overall SPARX aims to target adolescents by embedding therapeutic techniques and contents within an environment that is familiar with the target audience, in this case a role playing third person adventure game.

2.8.3 Overview of Computerized Psychotherapy

It can be observed that the range of computerized psychotherapy programs is vast and depending on the target audience, the content and method of relaying therapeutic information and techniques varies. However similar to Beating the Blues and SPARX, one of the biggest concern behind the automation of psychotherapies are the limitations of the computer to emulate the empathy or human qualities of a therapist. This has become a concern for therapies that rely on the subject to therapist relationship.

This project focuses on the creation of a therapeutic game based on the techniques behind Secure Self-Attachment Therapy. The reason is that Secure Self-Attachment Therapy does not require for there to be a bond between a subject and a therapist. The bond that is focused on is between the subject and his or her self-trust or inner child, which is achievable for most people. Hence the computer program would not have to emulate human compassion and empathy but only provide a platform where the subject can learn and explore the therapy techniques with oneself.

Chapter 3

Design and Development

3.1 Game Structure

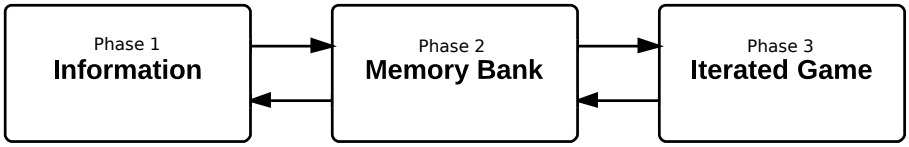


Figure 3.1: Flow chart of the basic overview of the game structure

For the effectiveness of the therapeutic aspect of the game, the flow of the game was made to be based on the structure of the Secure Self-Attachment Therapy. The game is split into 3 phases. The first phase of the game will solely be based on relaying information towards the workings of the game, scientific principles of the therapy, the concepts of Attachment Theory and also general information about the brain and mental illnesses. This phase acts as a tutorial for the game and is made to be a requirement for the player to go through the topics before proceeding to the next phase.

The second phase aims to excite the emotional side of the player by revisiting childhood memories. This is achieved by having a "Memory Bank" which is implemented as an archive where the player can import media and information regarding their childhood and build a growing library of these contents. Photos can be imported in the form of photo albums with descriptions where the player can browse around and explore their memories. Songs can also be imported and listened to within the game with the ability to add custom lyrics. Another form of content is the ability to enter journal entries, where players can remember childhood memories, stories or events and record them down and read them in the future. Lastly, the player can manage a library of affirmations which are short phrases that aims to convey helpful messages to the players. All these contents are not only stored in the "Memory Bank" for viewing purposes but also used in the next phase.

The third phase is the therapeutic portion of the game. This phase requires the player to perform physical or imaginary based exercises that invoke positive emotions to their inner child. These exercises would emulate the actions performed by a mother to her children. In this phase, players is also instructed to perform profile extension exercises which help develop the content in the "Memory Bank". Together with the "Memory Bank", the player would eventually associate positive emotions from the exercises with the player's childhood or inner child.

The second and third phases are played alternatively so the player would constantly be indulged in childhood memories while performing therapeutic exercises with their inner child. This would theoretically increase the effectiveness of the psychotherapy.

3.2 Frameworks

In this project, the game engine Ren'Py was used to develop the Secure Self-Attachment Therapy game. Ren'Py[30] is a game engine built specifically for games that are rich in text, images and sounds. It has many useful features that aids the development process of the game including libraries to build graphical interfaces, saving and loading features and other useful features. Most importantly, since the game engine is built on Python. It is able to run normal Python code when more complicated features are needed. Since the game engine was built on top of a high level programming language, it was the ideal choice for this product which involved rapid prototyping.

3.3 Design

Throughout the game, there were many design decisions that were made in hopes of making the game easier to play and increase the therapeutic aspect of the game. In this section we will explore these design decisions that were made.

3.3.1 Tamagotchi Effect

The "Memory Bank" or phase 2 of the game gains many inspirations from a Japanese toy named "Tamagotchi" released in 1996. This egg shaped toy contains a simulation of a virtual pet. The aim of the toy is to raise this pet from an egg to its adult form and it's growth depends on the frequency and quality of activities that you do with the pet. The toy is based on the attachment that the owner forms with the creature and hence the owner looks after the creature acting as its caregiver. There are many other toys and games that is based on the attachment the player forms with the object within the game or toy. The concepts behind Tamagotchi can be implemented to replicate the attachment that similar games and toys emulate.

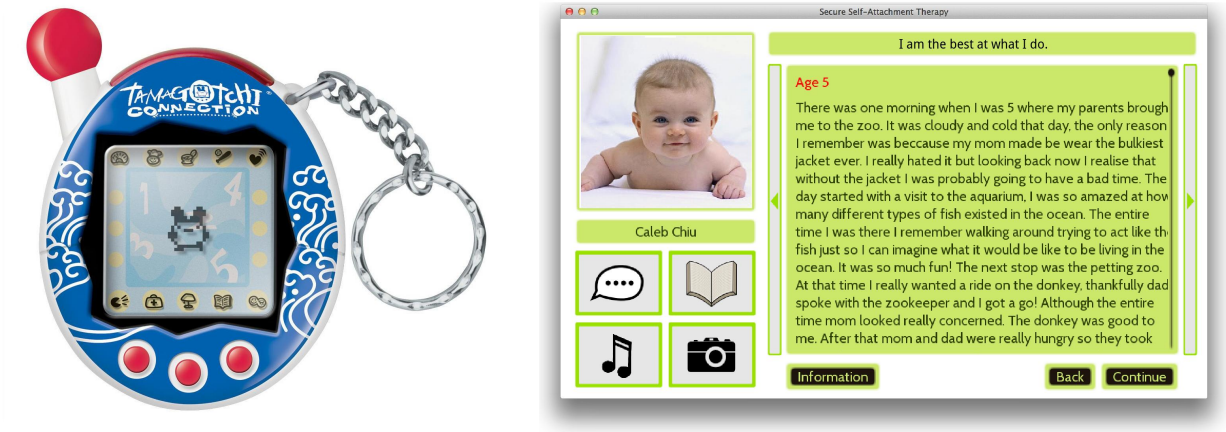


Figure 3.2: Comparison of the Tamagotchi and the Memory Bank

In the game, the "Memory Bank" serves as the object of attachment, representing the player's inner child. The more the player adds to or interacts with the contents of the "Memory Bank" will deepen the bond that the player will have with the inner child. The activities are represented similar to the interface found on the Tamagotchi with a visual representation of the desired content the player wishes to interact with. This can be observed in Figure 3.2, in the Tamagotchi the activities are found on the top and bottom of the display whereas in the Secure Self-Attachment Therapy game, the activities are found on the lower left portion of the Memory Bank. This design aim is to not only make features more accessible and more visually appealing but also to help create a stronger attachment to the inner child.

3.3.2 Minimalism

The purpose of the game is for the player to learn how to self-reflect and to engage in an emotional experience with one's inner child. It is important that the player eventually forms a strong bond with the digital representation of their inner child. With this purpose in mind, it was decided to implement a minimalistic design to keep visual distractions to a minimum to allow the players to focus on the therapeutic aspect of the game.

This minimal design concept is implemented throughout the game. The entire game uses a green, white and black coloured theme for simplicity. For example all the menu items have a green background so the player would always know whether an area is interactive and is of importance. By having a consistent theme, the player can spend less time learning the workings of the game itself.

Another area where minimalism is implemented is through all the images and graphics used within the game. This includes the informational slides and diagrams, button graphics and other visual items in the game. All details was kept to a minimum to make sure there are no distractions and also with more general images, players will be more likely to relate to them and learn more from the images. For example in the game, a person is portrayed as a stick figure which is widely and commonly recognized as a symbol for a person. These design implementations can be observed in Figure 3.3.

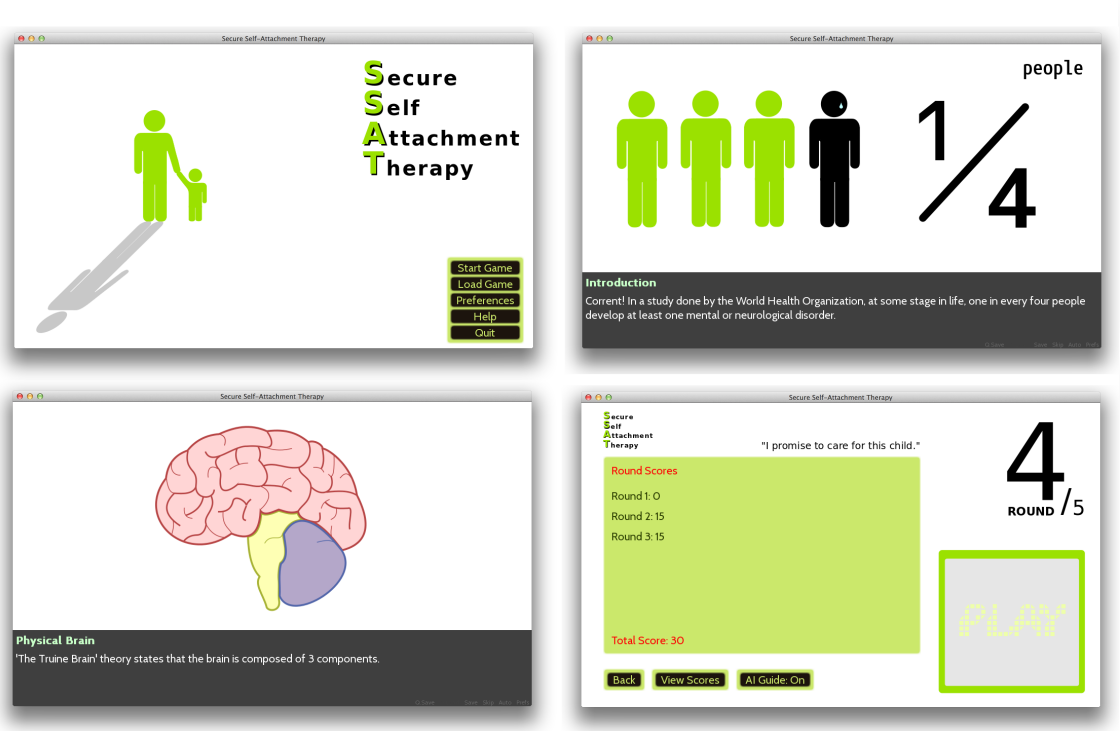


Figure 3.3: Screenshots of Secure Self-Attachment Therapy depicting the consistent theme

Chapter 4

Final Product

4.1 Description

Secure Self-Attachment Therapy is a psychotherapeutic tool where the player can learn and practice the techniques behind the therapy. As discussed in the design, the therapy is split into 3 phases to reflect on the steps behind the therapy itself. Phase 1 is to inform the player of the scientific background of the game and also serves as a tutorial in order to play the game. This phase is implemented through informational slides with visual graphics. The aim of phase 1 is to excite the player's cognition which is essential to the therapy since the player must be aware of the workings of the therapy and learn to become self reflective.

Phase 2 is where the player builds the profile of their inner child using the "Memory Bank". The Memory Bank is a menu where the player has access to all their imported and input data that concerns their childhood. These data are not only stored int he Memory Bank but also used in the later phase which is the iterated game portion of the tool. From the Memory Bank, the player can interact with these contents. The types of content that is available are music, photos, journal entries and affirmations. For music, the player has the ability to import songs which can be listened to and managed by within the game. Similarly, photos can be imported, managed and viewed in a format of a photo album. The player can also input journal entries recording stories and events that may be of importance. Lastly, the player can manage their list of affirmations at the Memory Bank. To summarize, The Memory Bank is designed to be a convenient platform where all data relating to the player's inner child content can be accessed and manipulated. The data stored in this phase are used in the next phase.

Phase 3 is the iterated game portion of the tool. It provides a platform where the player can perform therapeutic techniques or other exercises which extend the Memory Bank. In this phase, the player is asked to perform 5 rounds of exercises. For each exercise performed, the player gains a score which is accumulated to give a total score at the end of the rounds. The therapeutic exercises uses the data from the Memory Bank in order to make the exercises more personal and engaging which would increase the effectiveness of the therapy. Also, upon entry to this phase, the program prompts the user to rate their stress level as well as giving the users questions from Beck's Depression and Anxiety Inventory which will be explained in the later sections. These results are used as well to assess which exercises are given to the player depending on the stress level of the player. Lastly this phase features an Artificial Intelligence Guide which is an artificial agent which emulates human learning behaviours. The A.I. Guide is implemented as a guide to aid players to decide which type of exercises to perform.This feature can be toggled on or off and is further explained in later sections.

Overall the 3 phases reflect the steps that are necessary for Secure Self-Attachment Therapy. These phases are individually examined in the following chapters but an overview of the entire structure of the game can be observed in Figure 3.1. With the removal of the A.I. Guide, the structure of the

game changes to compensate for the removal of the A.I. Guide module, the alternative structure of the game with the A.I Guide turned off is given in Figure .

4.2 Game Logic

The game stores the player's pay-off matrix that keeps track of the player's progress. The game outcomes that the player chooses at the end of each round affects the change in this internal pay-off matrix. This pay-ff matrix is initialized with the values represented in Figure 2.1. The parent's pay-off values are reinforced when they choose to 'Attend' as shown in Figure 2.4 and the child's pay-off values are reinforced if the outcome involves the child going as shown in Figure 2.6. In this project the parent's reinforcement rate is set at $r = 1.02$ and the child's reinforcement rate is $s = 1.05$.

The process flow chart of the game logic is given in Figure 4.1. When a round is started, it prompts the user to select an exercise. If the A.I Guide is disabled, the player simply chooses an exercise to perform. If the A.I Guide is enabled, then the game instructs the A.I Guide to make a move. The internal variables in the A.I. Guide is then updated and the results are relayed back to pick an exercise for the player. Once the exercise is completed, the action checker checks the game outcome of the exercise and uses this information to update the player's internal pay-off matrix. Then the game checks whether the action "Attend, Go" is a Pareto Optimal Nash Equilibrium meaning that the player will choose to 'Attend' and 'Go' for every subsequent round, representing a transition to a secure attachment interaction. If it is the Pareto Optimal Nash Equilibrium, then the player wins the game, and is shown a victory screen. Whereas if it is not, then the scores are updated and it checks whether there are any more rounds in the set. If there is, the player is returned to the Phase 3 menu but if the set is completed, the player is returned to Phase 2.

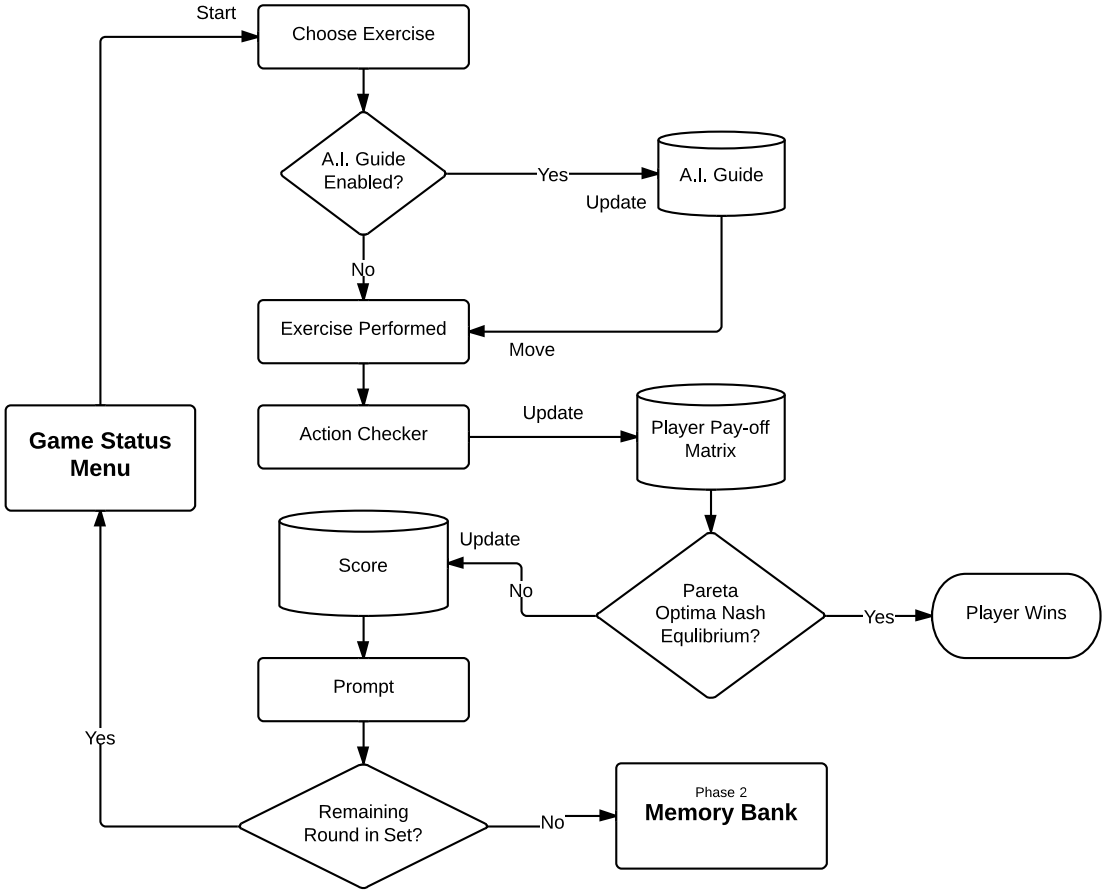


Figure 4.1: Process flow chart of the Game Logic in Phase 3

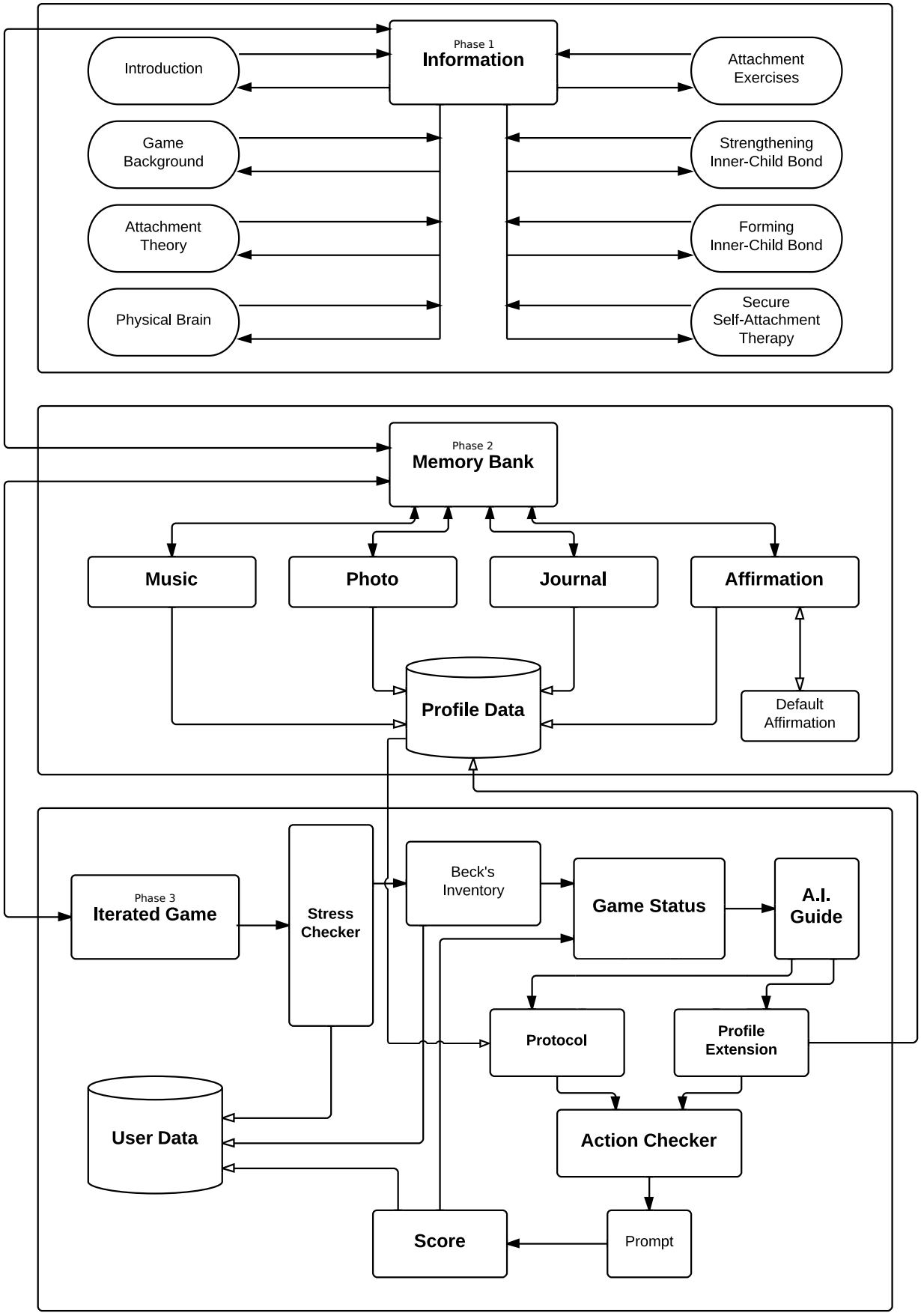


Figure 4.2: Structure flow chart for the Secure Self-Attachment Therapy game with A.I Guide

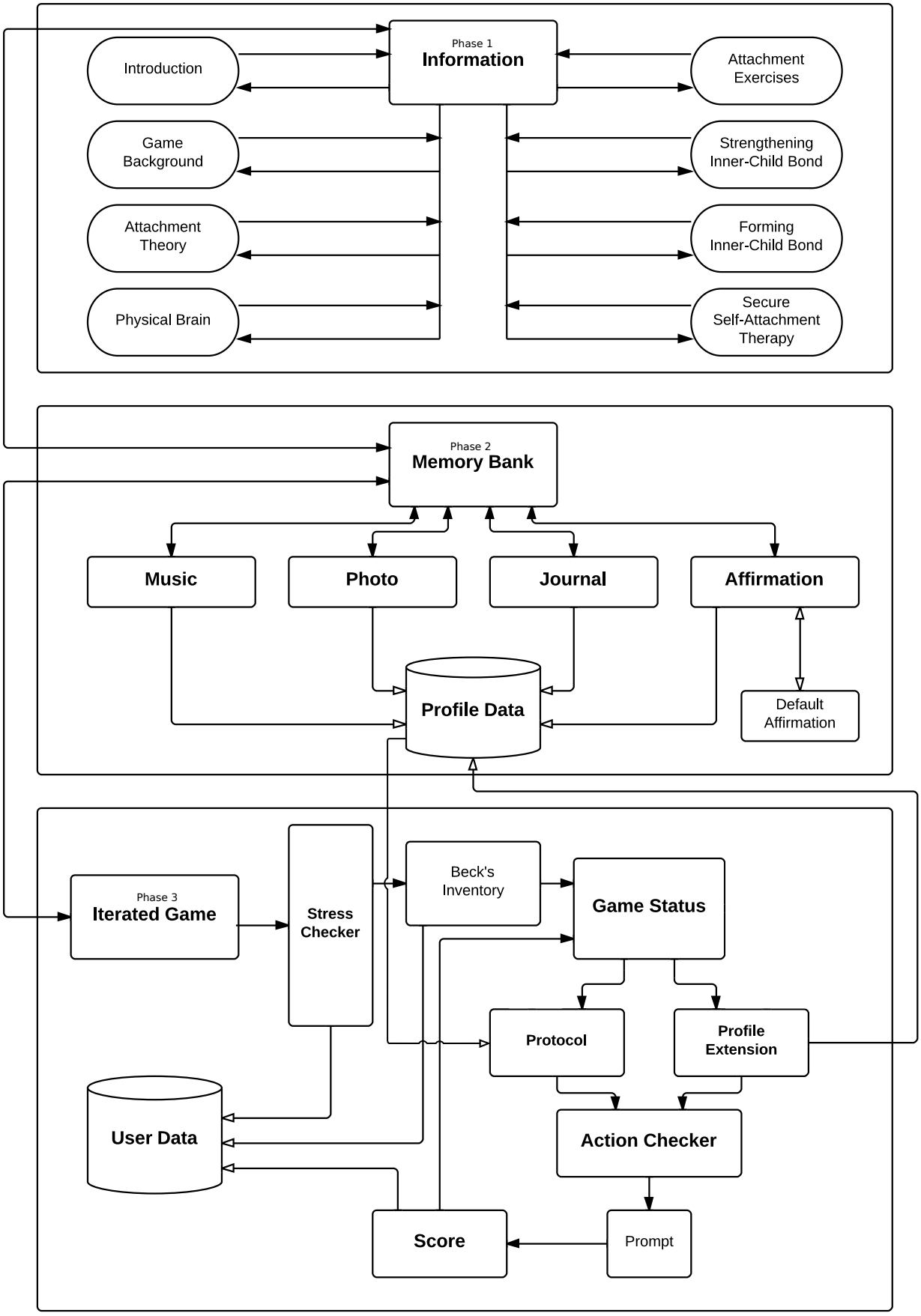


Figure 4.3: Structure flow chart for the Secure Self-Attachment Therapy game without A.I. Guide

Chapter 5

Phase 1: Information

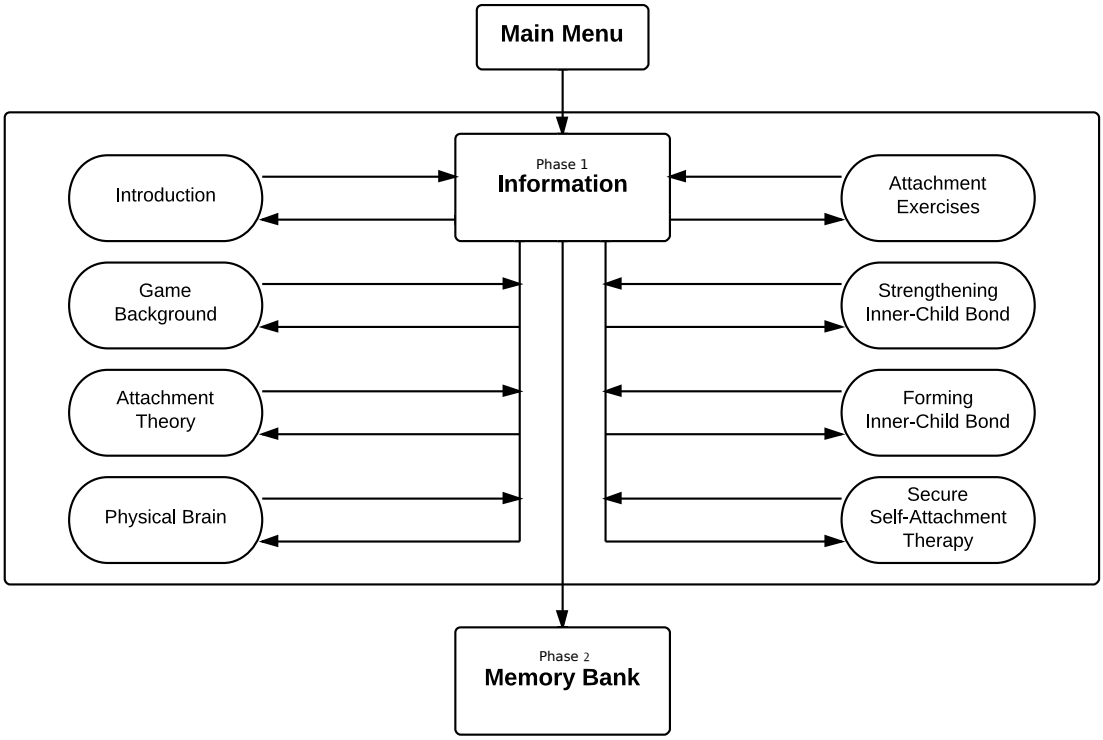


Figure 5.1: Structure flow chart for Phase 1: Information

5.1 Overview

Phase 1 is the informational part of the therapy tool which is responsible for exciting the cognitive portions of the player's brain. The structure of the phase can be observed in Figure 5.1. When the game is started the player is at the main menu. If it is the player's first time playing the game, when the player starts, they would enter phase 1 where they must complete all the topics within it which are labelled in Figure 5.1. The topics are presented as visually engaging slides with animations and transitions to keep the player interested. Once completed, the player is presented with the option to review any topics or proceed with the creation of the inner child's profile. If the player chooses to proceed, the flow of control moves into Phase 2. Whereas if the player wishes to review any topics, a menu with buttons leading to each topic is presented to the player.

5.2 Features

In this phase, the information is given in the form of visual engaging slides. For each slide, the textual information is given at the bottom of the screen. Examples of these informational slides are shown in Figure 5.3. Also to keep the attention of the player, the players are presented with questions where the answer affects the content of the following slides, such example is shown in Figure 5.2. This is implemented so that the player would learn through interactive opposed to simply reading information off static slides.

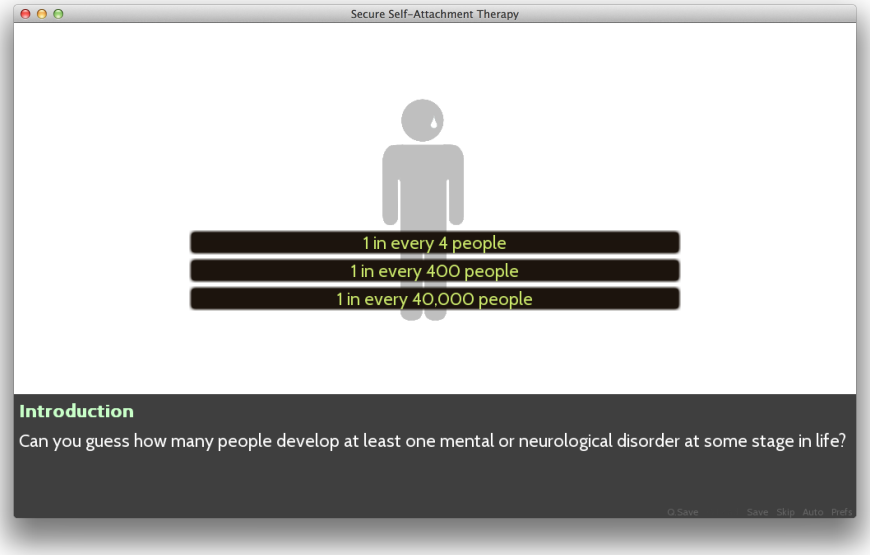


Figure 5.2: An Example of an interactive question slide in Phase 1

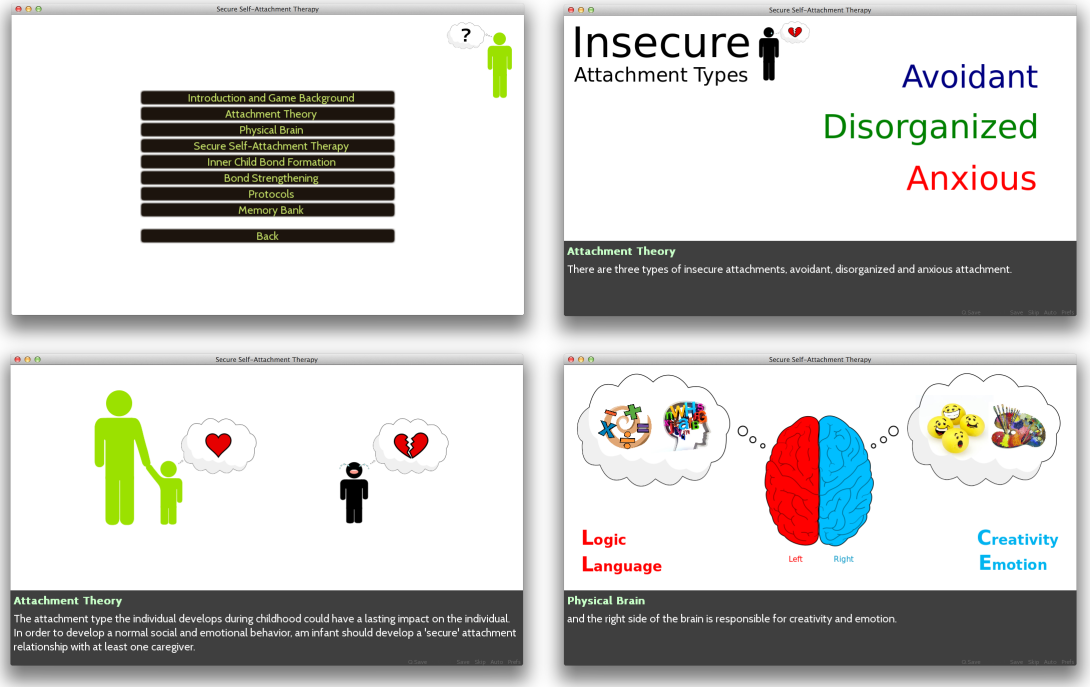


Figure 5.3: Screen shots of informational slides in Phase 1

Chapter 6

Phase 2: Memory Bank

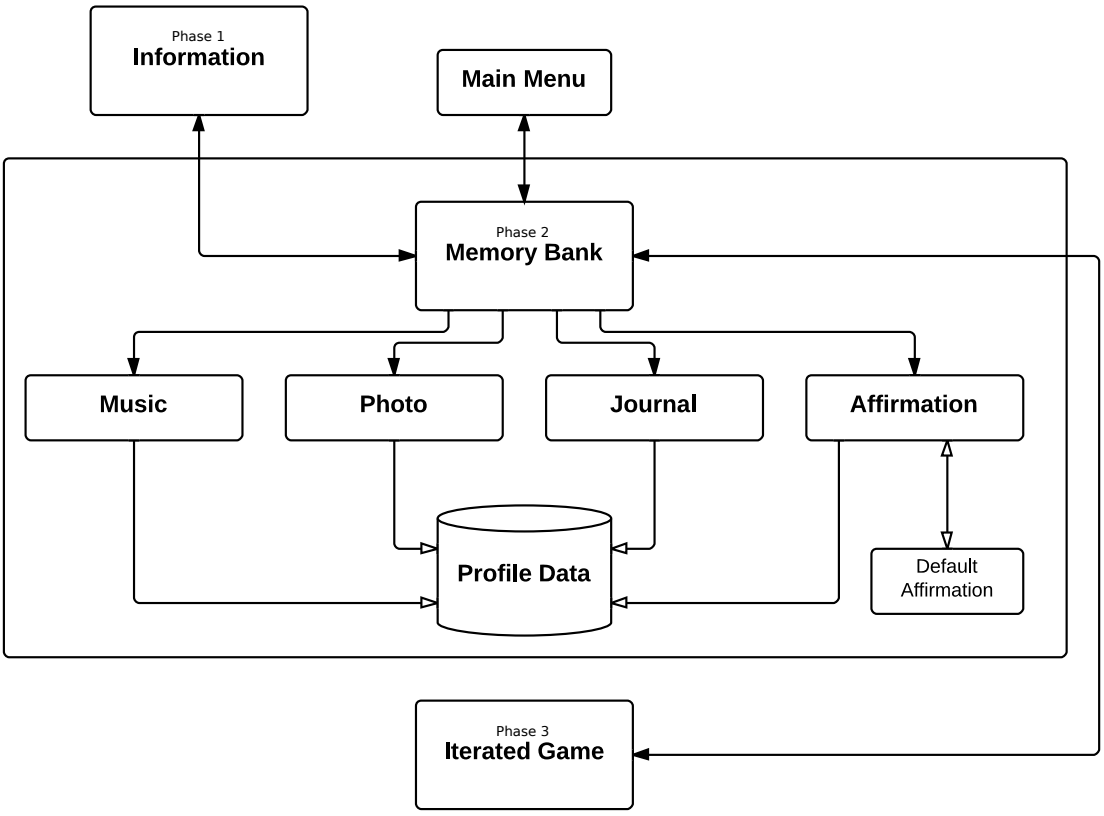


Figure 6.1: Structure flow chart for Phase 2: Memory Bank

6.1 Overview

Phase 2 is the part of the therapy tool responsible for the exciting the emotional portions of the player's brain. This is implemented through a "Memory Bank" where the player can add, interact and manipulate with the contents which builds the player's inner child profile. The structure of the phase can be observed in Figure 6.1. The Memory Bank can be accessed through Phase 1 or directly from the Main Menu. Also the player is able to return to Phase 1 at any time in the Memory Bank in case the player wishes to review any informational topics.

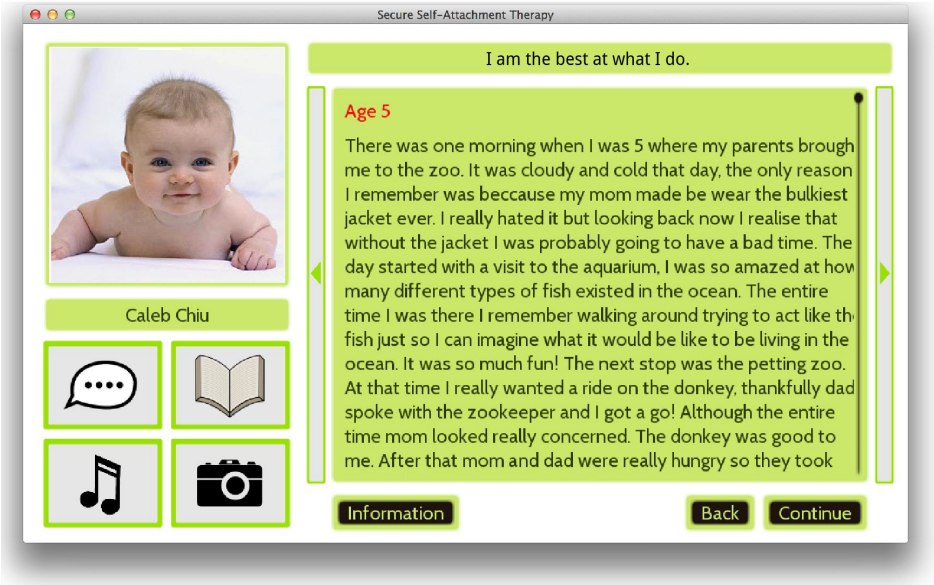


Figure 6.2: Screen shot of main screen in Phase 2: Memory Bank

6.2 Screen Layout and Features

The layout of the Memory Bank main screen is important. It is designed to give the player a summary of the contents of which they have imported or input. This layer can be observed in the main screen screen shot found on Figure 6.2. Starting from the upper left area of the screen contains the player's profile picture. This would be a photo the player has imported that is particularly emotionally evoking. It is important for the therapy that the user always has a photo from childhood of particular importance that evokes strong emotions within the user. By having the profile picture on the main screen of the Memory Bank, the player is always reminded of the emotions that the photo entails. Below the profile picture is the player's name in order to give the inner child profile a sense of realism.

On the lower left area of the screen are the different options or "activities" that the player has access to. They include the "Music Room", "Affirmation Builder", "Journal Entry" and the "Photo Gallery". These options can be selected by clicking on the corresponding buttons represented by a visual representation of the activity. This design was inspired by the Tamagotchi Effect explained earlier. Each of these options are explored in detail in the following sections. These activities allow the user to add, manipulate and interact with the contents in the Memory Bank which are all stored in the program's "Profile Data". These contents are used in the next phase as part of the therapeutic exercises.

The upper right area of the screen contains a long text box which displays a random affirmation stored in the "Affirmation Builder". These are short phrases which the player's relate to or have strong emotional connections with. This is to help invoke the emotional portion of the brain which is essential for this therapy. Any action performed on this screen will change the content of this affirmation box.

Directly below this affirmation box is the "Journal Viewer". It contains all the journal entries that the player can input throughout the course of the game. There are buttons on either side of the journal page to cycle through the different entries. The view-port is also scrollable in case the particular journal entry is long. This allows the player to have the ability to review past stories and events before proceeding to the next phase which is achieved by clicking on the "Continue" button on the lower right corner of the screen. If the player wishes to review any informational topics, the "Information" button would bring the player back to Phase 1.

6.3 Music Room

6.3.1 Features

The Music Room contains all the music imported into the game by the player. On the main screen shown on Figure 6.3, the player can cycle through their music collection and listen to them within the game. The top of the Music Room Screen displays the current song title as well as the track number. Below this information are the lyrics to the song which can be input by clicking on the "Add Lyrics" button on the left portion of the screen. The player can cycle through their music collection with the buttons on the side of the lyrics box and the player can also play or stop the music with the corresponding buttons at the bottom of the screen. Once a song is played, the player can proceed to other areas of the game with the music playing in the background. This feature is important because music is proven to be an effective tool in exciting the emotional portion of the brain as discussed earlier, hence it was decided that the user should be able to listen to their music collection in the background.

6.3.2 Music Import

Simplicity was aimed for in the implementation of the music import function. In order to import a song, the player simply drags a music file from their computer into the game directory's "Music" folder as depicted in Figure 6.4. Once the file is in the folder, it would automatically appear inside the game.

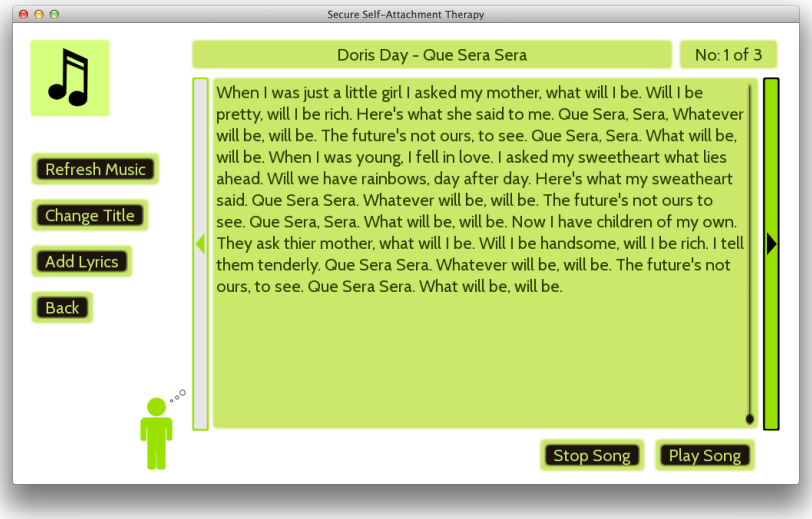


Figure 6.3: Screen shot of main screen in Phase 2: Music Room

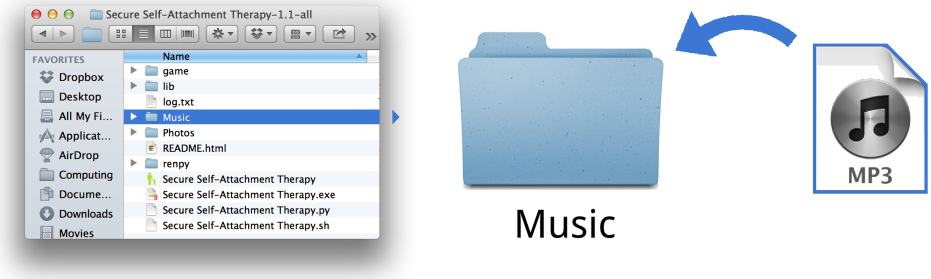


Figure 6.4: Instructions to import songs into the Music Room

6.4 Affirmation Builder

6.4.1 Features

The Affirmation Builder is the portion of the game that allows the player to manage their affirmation list. On the main screen shown on Figure 6.5, the player can view the affirmations that they have selected, as well as having access to add or remove from this list. On the left side of the affirmation main screen are the filter buttons. When clicked on either one of the buttons, the list of affirmation will filter and only show affirmations corresponding to the clicked type or genre of affirmation. It is important to distinguish between the different types of affirmations so the player has the ability to only view affirmations of a particular type.

To add an affirmation, the player simply clicks on the "Add Affirmation" button. The game will then prompt the user to select whether they want to add a custom affirmation or an existing one as shown on Figure 6.6. If the player chooses to add a custom affirmation, the game prompts the player to type in the affirmation. Upon completion, the game will ask the player to associate the custom affirmation with a type or genre. When selected, the player is returned to the main screen and the custom affirmation would be added to the list. If the player chooses to add an existing affirmation, the game loads in predefined affirmations and displays it similar to the main page. The player can filter the default affirmations with the filter options and once an affirmation is found, the player simply clicks on the affirmation and clicks on the "Add Affirmation" button. The player would then return to the main screen with the existing affirmation added to the list. To remove an affirmation, the player simply clicks on an affirmation in the list and clicks on the "Remove" button.

Figure 6.5: Screen shot of main screen in Phase 2: Affirmation Builder

Figure 6.6: Screen shots of the Add Affirmation function (Custom and Existing Affirmation)

6.5 Journal Entry

6.5.1 Features

The Journal Entry activity allows the player to input stories or events that is of significance to their childhood. The entries input in this portion of the game is added to the Profile Data and used to be displayed on the main screen of the Memory Bank as well as being used in the next phase for the therapeutic exercises. When the player clicks on the visual button for the Journal Entry, the game asks the player to enter the age they were at the time of the story or event as shown on the left screen shot in Figure 6.7. When a valid answer is given to the game the player is then able to write their journal entry on the the right screen shot in Figure 6.7. Once completed, the player simply confims by pressing 'Enter' on their keyboards and the game will return to the main screen of the Memory Bank displaying the new journal entry.

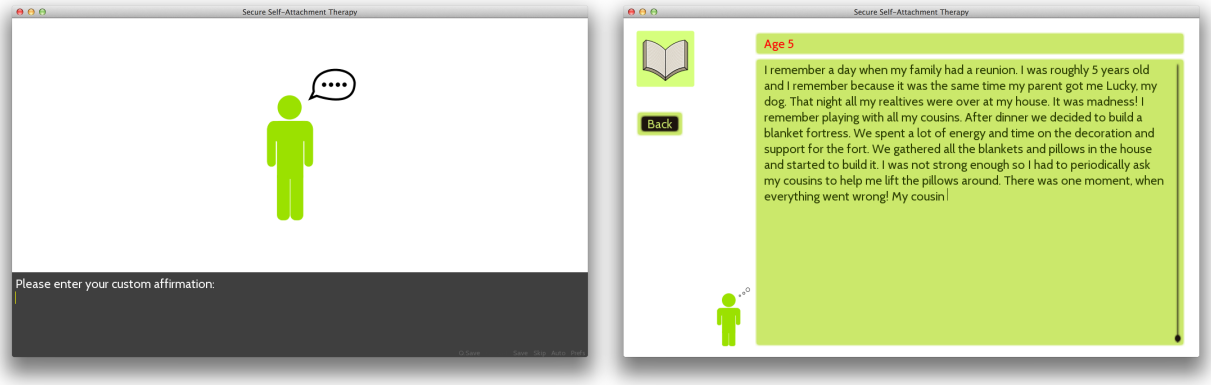


Figure 6.7: Screen shots of the Journal Entry process

6.6 Photo Gallery

6.6.1 Layout and Features

The Photo Gallery is contains all the photos that the user has imported. The screenshot of the main screen of the Photo Gallery can be viewed in Figure 6.8. From this screen, the player can cycle through all their photos as if they were in a photo album. With each photo, if the player scrolls underneath, the description of the photo can be found. This is so that the player can be reminded of the importance of the photos. All the input data is stored in the Profile Data and used in the later phase.

On the top of the screen is contains the title of the photo and the photo number that is selected. Below that is the view-port containing the photo itself and the photo's description directly below it. The photos can be cycled through by pressing the buttons on either side of the view-port. On the left portion of the screen are the functions of the Photo Gallery. The player can change the title of the photo, add their custom description for individual photos or to select a photo for the Memory Bank's profile picture. These functions are observed in the screen shots found in Figure 6.10.

6.6.2 Photo Import

The import process was made the same as the music import feature. This is to maintain the game's simplicity and consistency. In order to import a photo, the player simply drags a picture file from

their computer into the game directory's "Photos" folder as depicted in Figure 6.9. Once the file is in the folder, the photo will automatically be uploaded into the Photo Gallery.

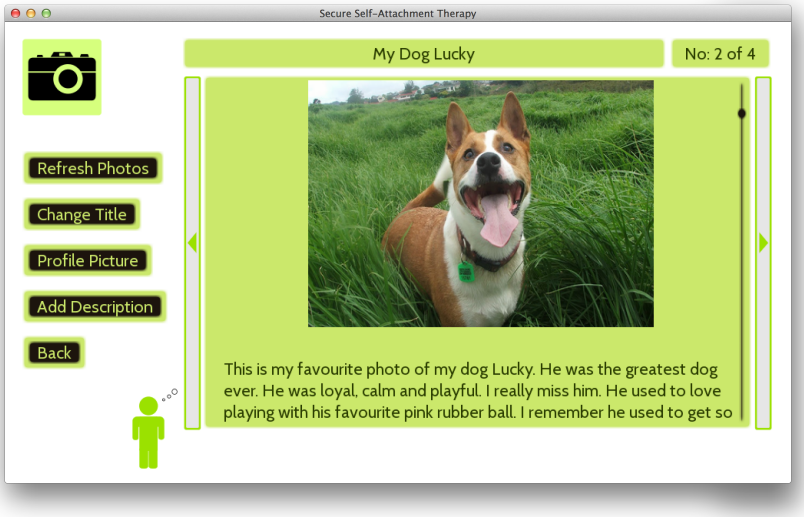


Figure 6.8: Screen shot of the main Photo Gallery screen

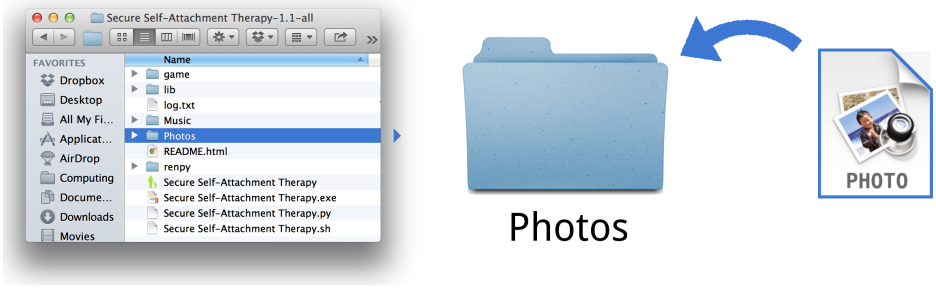


Figure 6.9: Instructions to import photos into the Photo Gallery

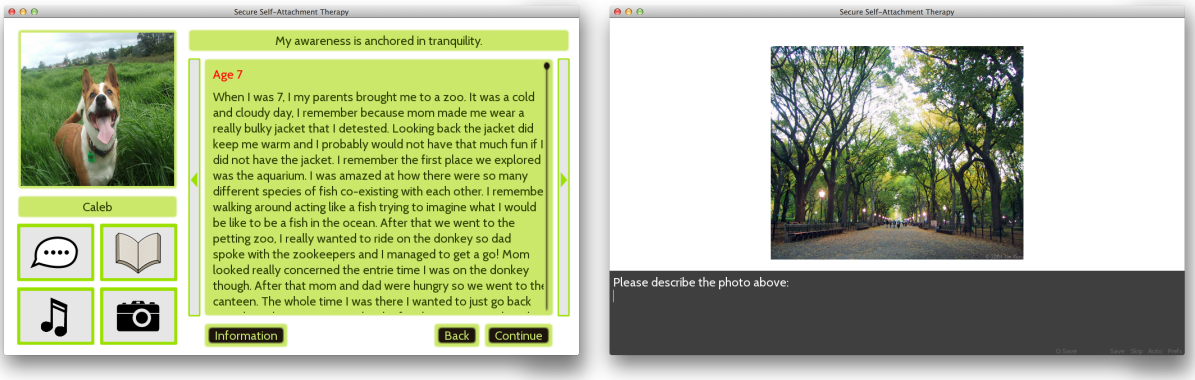


Figure 6.10: Memory Bank after profile picture change and "Add Description" screen

Chapter 7

Phase 3: Iterated Game

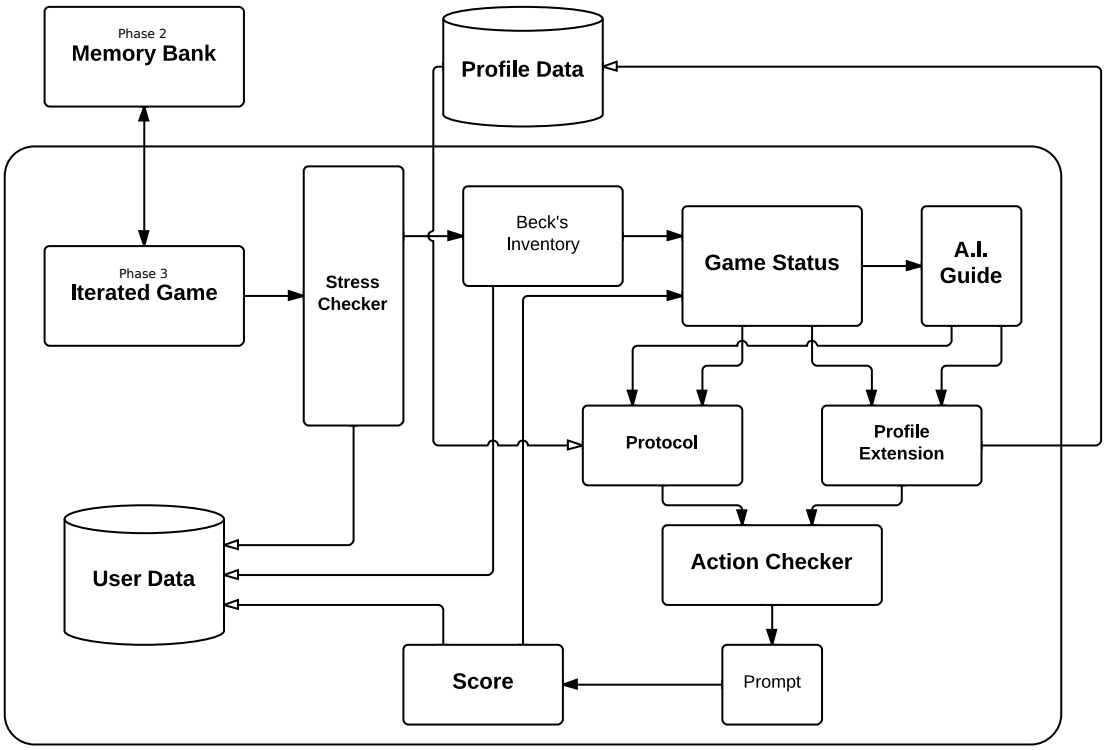


Figure 7.1: Structure flow chart for Phase 3: Iterated Game

7.1 Overview

Phase 3 is the iterated game portion of the tool responsible for forming and strengthening the bond between the player and their inner child. With the A.I. Guide enabled, the structure of this phase can be observed in Figure 7.1. Whereas the structure for the phase if the A.I. Guide is disabled can be observed in Figure 7.2.

The following is a brief description of the game flow. When Phase 3 is entered, the game gives the player a couple of informational slides to explain the workings of the iterated game. After the game prompts the user to input their stress level as well as answer questions from Beck's Anxiety or Depression Inventory. Once completed, the game then transitions to the main screen for Phase 3 named the "Game Status" shown on the screen shot in Figure 7.3. Each set of the game consists of 5 rounds that the player must perform. This is achieved by clicking on the "Play" button. The player

then chooses to perform Secure Self-Attachment Therapy protocols or profile extension exercises. If the A.I. Guide is switched on, then an intelligent agent would select the exercise for the player. After each round of exercise the game progresses into the action checker which checks whether the player performed the exercise and whether the player felt better after it. Then depending on the choices, the scores as well as the pay-off matrices for the player and A.I. Guide are updated and if there are more rounds to be played, the player is returned to the Game Status main screen. If the set is finished, the player is returned to their Memory Bank. All the information gathered in this phase including the user's stress levels, question answers and scores are stored in the "User Data". Each component of this phase will be explored in the following sections.

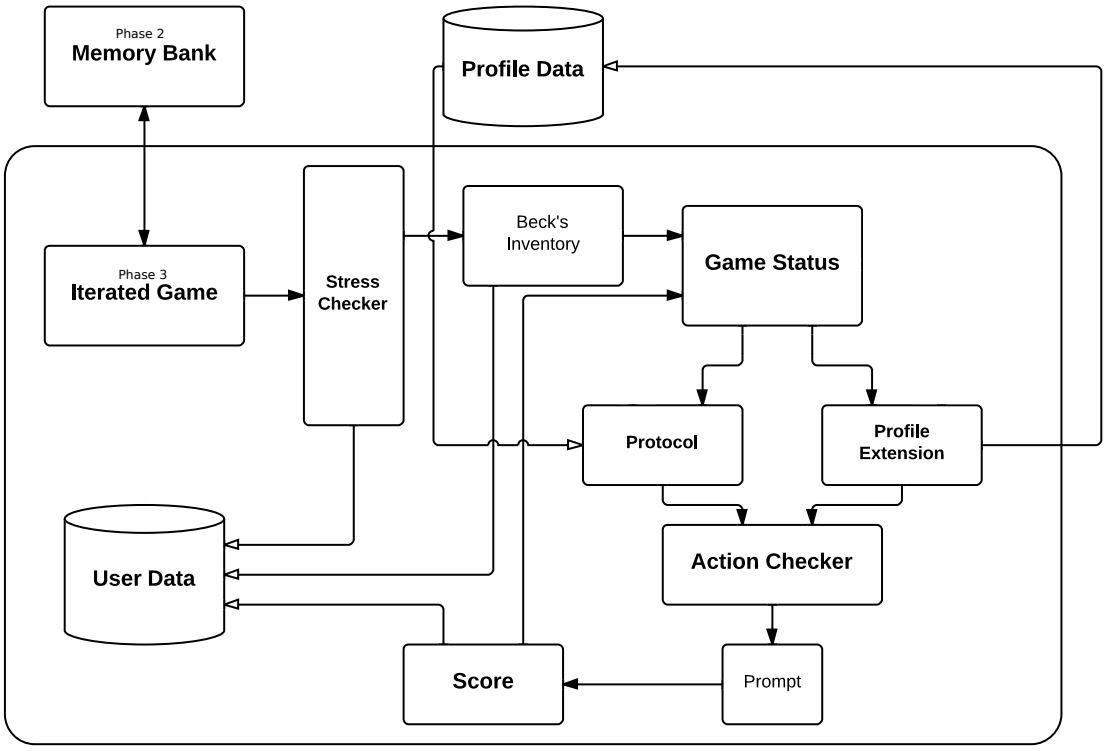


Figure 7.2: Structure flow chart for Phase 3: Iterated Game

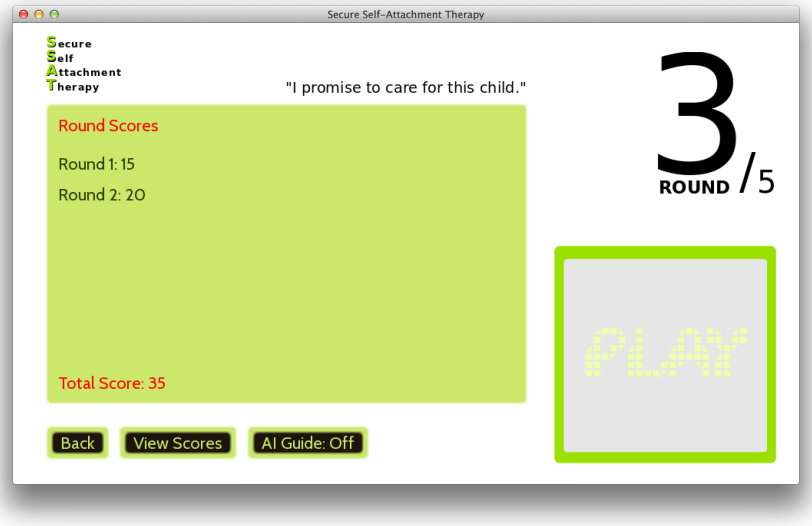


Figure 7.3: Screen shot of main screen "Game Status" in Phase 3: Iterated Game

7.2 Game Status Layout

On the Game Status main screen shown in Figure 7.3, the player can have a quick overview of their progress of their set. In the main green box, the player's round scores and total score is displayed. On the right of the score box is an indicator of which round the player is currently on. At the bottom of the screen are the functions in this phase. The "View Score" button brings the player to a score history page displaying the scores of all the previous sets. The "A.I. Guide" button toggles the intelligent agent on or off and the "Play" button starts the round.

7.3 Stress Checker

Before entering the Game Status page, the player is asked to enter their stress level as well as to answer a set of 3 questions from Beck's Anxiety or Depression Inventory which are chosen at random. The stress level is rated from 1 to 5 with an option to select "No Stress" as well as depicted in Figure 7.4. This stress level is recorded and added to the User Data. This stress level affects the type of Secure Self-Attachment Therapy protocols that are given to the player for the set. This is explored in the following sections.

7.3.1 Beck's Inventory

Beck's Anxiety Inventory and Beck's Depression Inventory are questionnaires designed to assess the severity of the subject's anxiety or depression accordingly. These questionnaires can be found in the Appendix of this report. Both sets of questionnaires consists of 21 multiple choices. The sum of the points are used as the indicator of the severity where the higher the total is, the more severe the anxiety or depression the subject is suffering. This is implemented into the game by having the player answer sets of 3 questions per set, an example can be seen in Figure 7.4. When a questionnaire is complete meaning that all 21 questions from either Beck's Inventory, the player is notified of the results and an analysis of the result. The answers and results are all then stored in the User Data where they can be retrieved later for reviewing purposes.

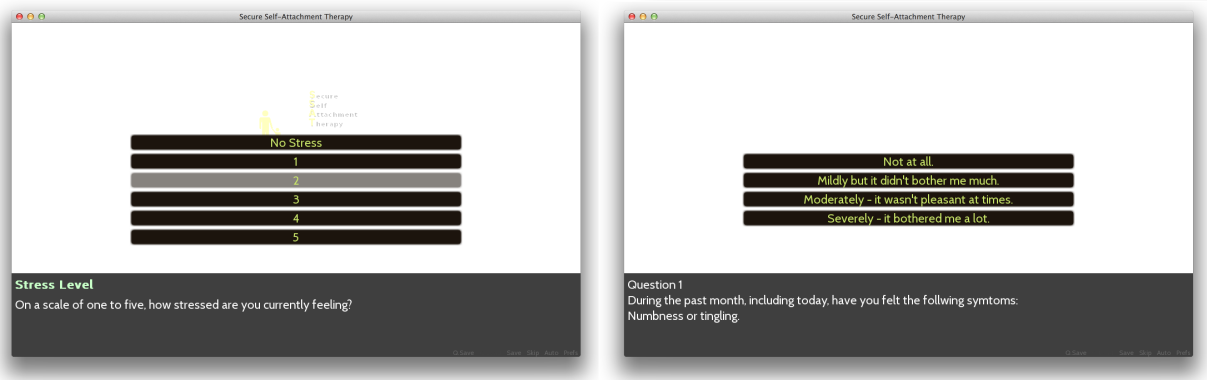


Figure 7.4: Screen shots of the stress checker and a question from Beck's Anxiety Inventory

7.4 Artificial Intelligence Guide

The Artificial Intelligence (A.I.) Guide is implemented in this game in order to aid the player in deciding which exercise to perform. The player has the option to toggle this feature on or off on the Game Status main screen. The A.I. Guide models the parent to child interaction from an insecure avoidant attachment to a secure one through behavioural learning. For each round, the A.I. Guide

Figure 7.5: Screen shot of the A.I. Guide selecting a Secure Self-Attachment Therapy Protocol

is prompt to make a move. If the A.I. Guide chooses to "Attend, Go" or "Attend, Don't Go" then the player is presented with a Secure Self-Attachment Therapy protocol. Whereas if the A.I. Guide chooses to "Ignore, Go" or "Ignore, Don't Go", the player is present with profile extension exercises. The reason behind this implementation is that the A.I guide would proceed to slowly form the secure attachment interaction based on human learning behaviours so the player would perform the exercises at a natural rate. However since the model is a simplification of the human learning behaviour, the A.I. Guide would be unable to model the complexity of an individual human so the decisions made by the A.I Guide may not be suitable for all players. Hence it was decided to let the players decide whether to have this feature enables or disabled in the game.

7.4.1 Implementation

In this project, two implementations of intelligent agents were developed. The first intelligent agent is based on the model developed by David Cittern's [26] implementation explained earlier and the second one is based on the development of Cai Zhou's [27] implementation. The following page describes as well as analyses the two implementations.

David Cittern Implementation

As explained in the previous chapters, David Cittern's implementation of the intelligent agent consists of the adult modelled with a Q learning learning behaviour with reinforcement learning and the child having a Best Response to Last Move (BRTLM) strategy. For this project, let the Cittern based implementation be named "Intelligent Agent 1". In this implementation, the parent agent is initialized with the following parameters; reinforcement rate $r = 1.02$, discount factor $\delta = 0.4$ and the exploration parameter $k = 2$.

The number of rounds necessary for a stable secure attachment interaction to be established and transitioned from an insecure avoidant attachment interaction was tracked. This process was repeated for 100 trials. The number of rounds necessary was averaged and is given as follows.

$$\bar{x}_1 = 332 \tag{7.1}$$

This means that it takes Intelligent Agent 1 an average of 332 rounds for the agent to choose "Attend, Go" for every round after. The game outcome distribution of the this process is shown in Figure 7.6 and 7.7.

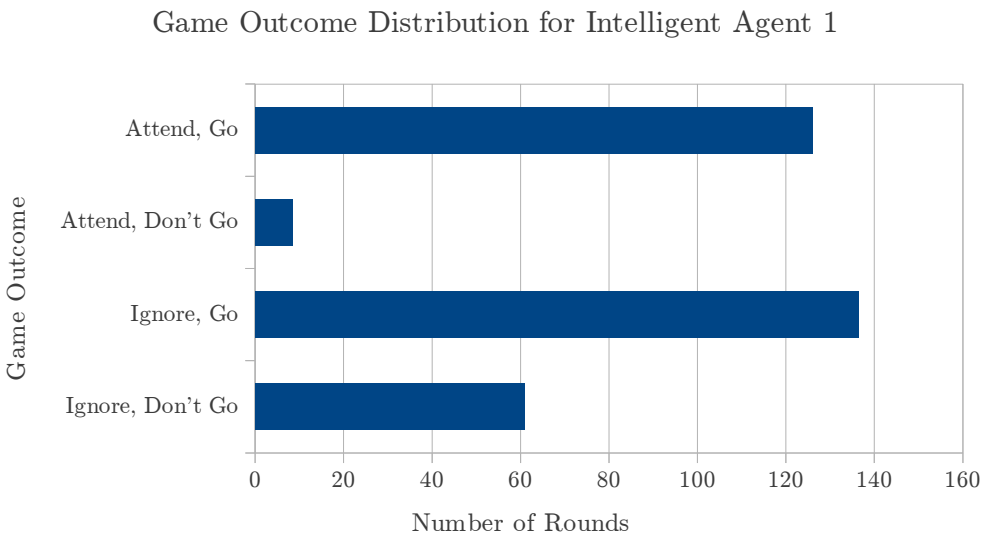


Figure 7.6: Bar Graph showing the Game Outcome Distribution for Intelligent Agent 1

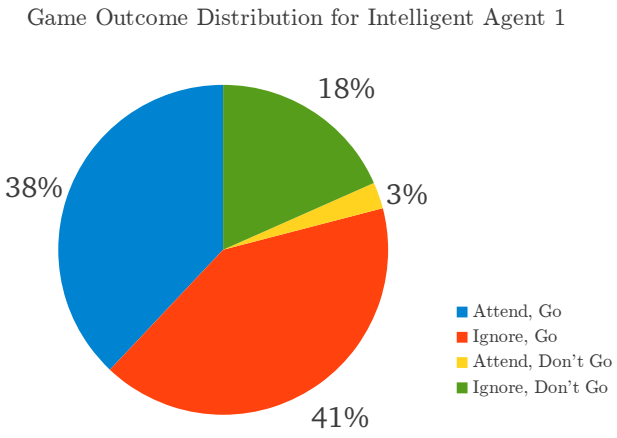


Figure 7.7: Pie Chart showing the Game Outcome Distribution for Intelligent Agent 1

Cai Zhou Implementation

Also explained in the previous chapters, Cau Zhou's implementation of the intelligent agent has both of the adult and child modelled with a Q learning behaviour with reinforcement learning. For this project, let Cai Zhou based implementation be named "Intelligent Agent 2". In this project the parent agent is initialized with the following parameters; reinforcement rate $r = 1.02$, discount factor $\delta = 0.4$ and the exploration parameter $k = 2$. The child agent are initialized with the following; reinforcement rate $s = 1.05$, discount factor $\delta = 0.4$ and the exploration parameter $k = 2$.

The number of rounds necessary for a stable secure attachment interaction to be established and transitioned from an insecure avoidant attachment interaction was also tracked. This process was repeated for 100 trials. The number of rounds necessary was averaged and is given as follows.

$$\bar{x}_2 = 285 \tag{7.2}$$

This means that it takes Intelligent Agent 2 an average of 285 rounds for the agent to choose "Attend, Go" for every round after. The game outcome distribution of the this process is shown in Figure 7.8 and 7.9.

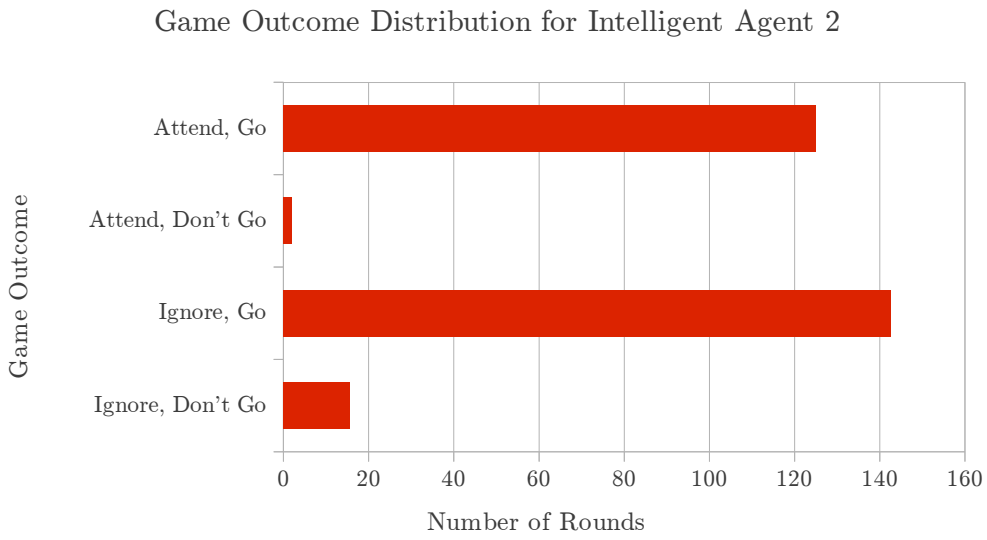


Figure 7.8: Bar Graph showing the Game Outcome Distribution for Intelligent Agent 2

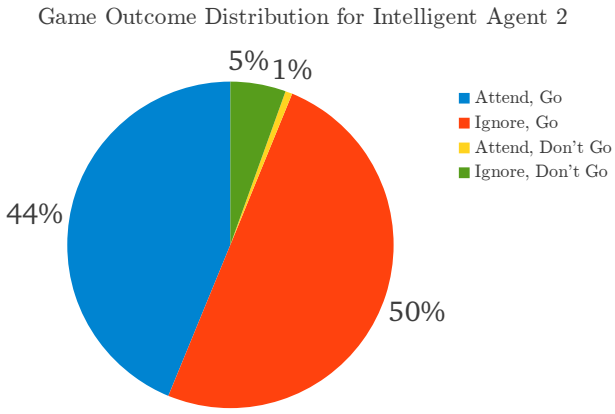


Figure 7.9: Pie Chart showing the Game Outcome Distribution for Intelligent Agent 2

Comparison

As we can see from the results Intelligent Agent 2 reaches a stable secure attachment interaction quicker than Intelligent Agent 1. This is expected since in Intelligent Agent 2, the multi-agent aspect of the model means that both the adult and child is enabled to guide the interaction patterns to one that represents a secure attachment relationship. However, in Intelligent Agent 1, the parent is the only agent who is able to guide this interaction since the child is constantly running a BRTLM strategy.

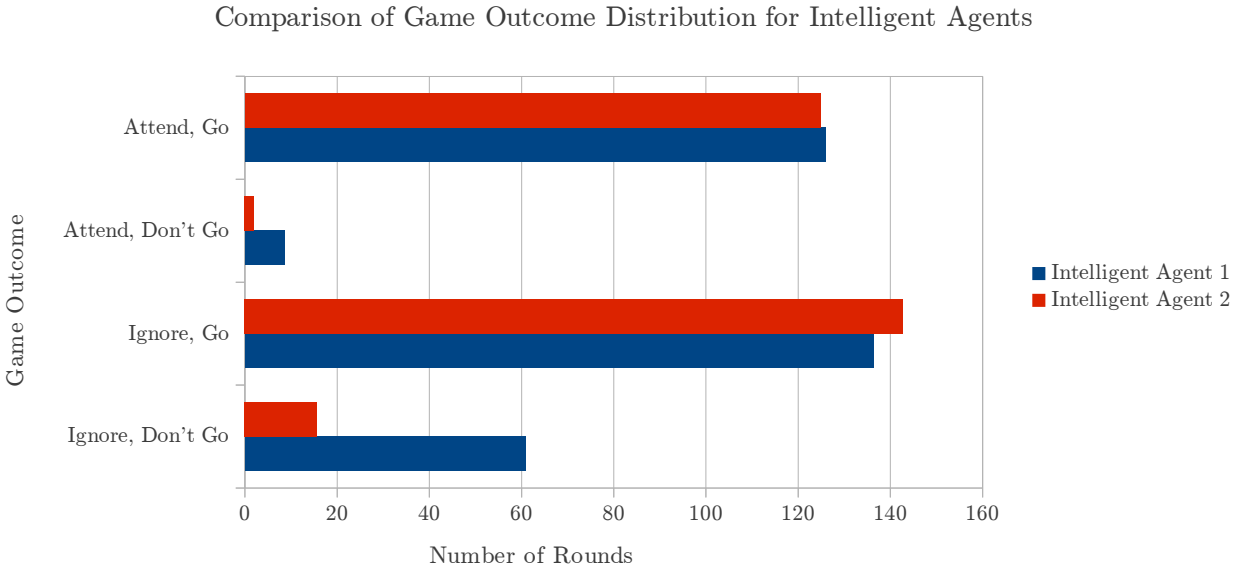


Figure 7.10: Comparison of the Game Outcome Distribution for the Intelligent Agents

The comparison for the game outcome distributions can be observed in Figure 7.10. For both of the intelligent agents, the most frequent game outcome is the "Ignore, Go" with the "Attend, Go" at a slight lower frequency. For Intelligent Agent 2, the frequency for "Ignore, Don't Go" is slightly higher. This is expected since this action is only reinforced in Intelligent Agent 2. The major difference between the data sets are the frequencies for the outcome "Ignore, Don't Go". This outcome is significantly lower than for Intelligent Agent 1. This means that Intelligent Agent 2 spends less rounds choosing actions relating to insecure avoidant attachment interactions and spend more rounds in actions that would lead to a secure attachment relationship.

In this project Intelligent Agent 2 was chosen as the A.I. Guide. This means that the game does not only keep a internal player pay-off matrix but also another one for the A.I. Guide.

7.4.2 Multiple Q Model

In this project, another approach of the Q-Learning algorithm was implemented. In the original approach, each agent would have a overall Q value per action that they could make at a given state. For example the adult agent would have a Q value for 'Attend' as well as a Q value for 'Ignore'. These values are updated through the Q update rule as the game processes.

However in this project, it was decided to split the Q values into smaller "Pre-Q Values". This means that the agent would have a "Pre-Q Value" for each of the action pairs in a given state as shown on Figure 7.11. These "Pre-Q Values" would represent the values the agent places on game outcomes given a action choice. The corresponding Q values are calculated with the "Pre Q Values" which are then fed into the behavioural policy for an action to be chosen.

The advantage of having a Multiple Q Model is so that a deeper representation of the intelligent agent can be made. The agent would not only have a value of a particular choice but also value

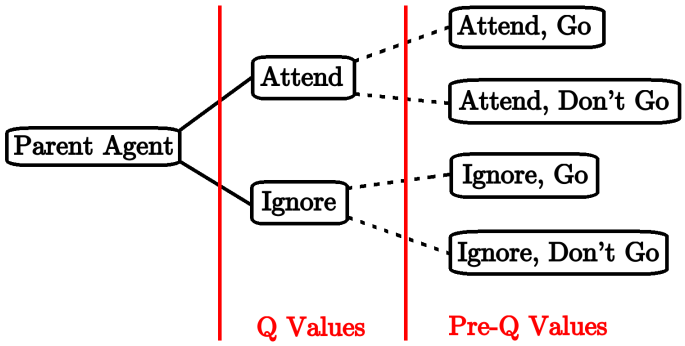


Figure 7.11: Diagram depicting the relations between Q Values and "Pre-Q Values"

they place on an individual outcome given an action choice. This would be important to track the the evolution of the values agents or players put on individual game outcomes throughout the iterated game model.

This model was used in the implementation of both Intelligent Agent 1 and 2. The results gathered correspond to that of the research done by Cittern[26] and Cai[27]. This means that the Multiple Q Model is reliable and stays true to the concept behind the Q-Learning Algorithm.

7.5 Scoring System

The scoring system acts as the reinforcement provider in the game. It indicates the quality of the action that the player has chosen. At the end of every round, the game transitions into the action checker. The game then prompts the player with two questions. Whether the player attempted the exercise and whether the player felt better from performing the exercise. The result gathered from these questions indicate the game outcome. If the player performed the exercise, this means that the adult part of the player decided to 'Attend' the inner child's distress. If the player felt better after performing the exercise, this means that their inner child picked 'Go' meaning it choose to seek the parent for relieve. Together, the action pair of the game outcome is found and this information is relayed to the game logic and A.I. Guide where the player's pay-off matrix and the A.I. Guide's pay-off matrix are updated. The points awarded to the players per round are given as follows.

$$\begin{aligned} Attend, Go &: \mathbf{20} \\ Attend, Don'tGo &: \mathbf{15} \\ Ignore, Go &: \mathbf{5} \\ Ignore, Don'tGo &: \mathbf{0} \end{aligned} \tag{7.3}$$

These points accumulate to a score out of 100 per set of 5 rounds. The scoring system is reflective of the reinforcement rule explained earlier and given in Equations 2.1 and 2.7. Since the player is encouraged to achieve higher scores, the parents would be more inclined to choose the actions that would promote secure attachment interactions.

7.5.1 Score Design

In the action checker screen in the game. As the player answers the questions to indicate their action choice, the player would receive a visual feedback as the questions are answered. This is implemented by having a visual representation of the player's adult self and inner child displayed on

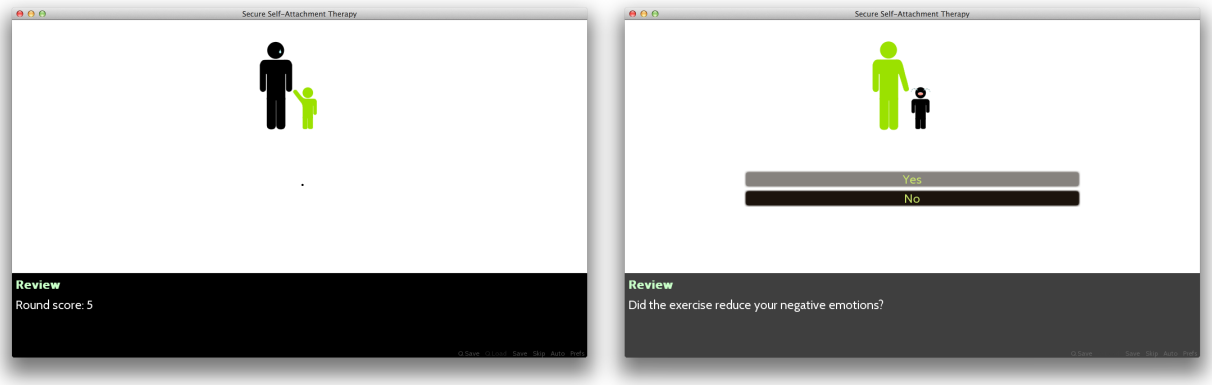


Figure 7.12: Screen shots of the Action Checker screen

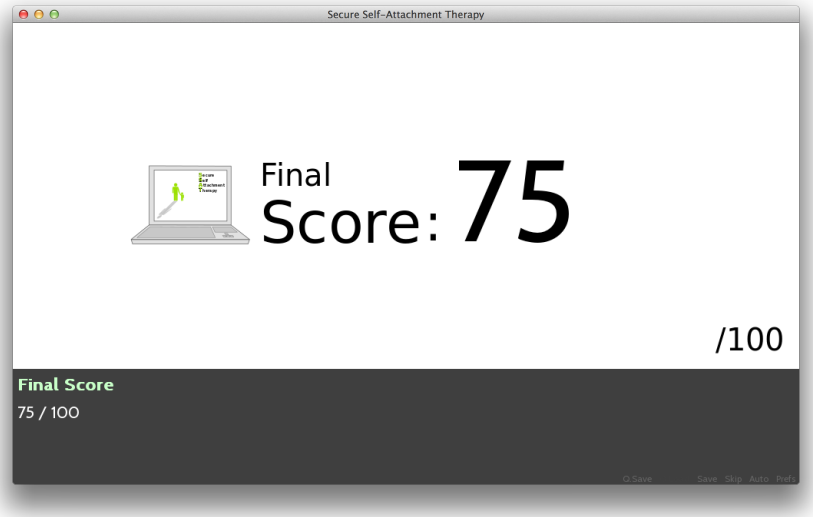


Figure 7.13: Screen shot the Final Score screen

the screen as shown on the example screen shots found in Figure 7.12. Initially they are displayed as being depressed. However, if the player chose that they attempted the exercise, the adult representation turns green and extends its arm towards the child. Likewise, if the player chose that he or she felt better after performing the action, the inner child representation would also turn green and hold the adult's hands. This visual guide compliments the scoring system increasing the need for the player to choose actions corresponding to secure attachment behaviours.

On top of showing the player their current score on the Game Status main screen, at the end of the set after 5 rounds of exercises, the player is presented with the Final Score screen. This screen displays the final score obtained by the player as shown in Figure 7.13 and is used as an indication that the player has completed a set. The player is then returned to the Memory Bank.

7.6 Iterated Game Exercise

In Phase 3, the player is asked to perform 5 rounds of exercises. These exercises are split into two types; Profile Extension Exercises and Secure Self-Attachment Therapy Protocols. Both of these exercises require the player to interact with their Memory Bank contents and aims to promote positive emotions. Since this phase focuses on the forming and strengthening of the player to inner child bond, Profile Extension Exercises seek to ensure the formation of this bond while Secure Self-Attachment Therapy Protocols seek to only strengthen this bond.

7.6.1 Profile Extension Exercise

In order to increase the effectiveness of the therapy, the player must populate their Memory Banks with content. The more content the the Memory Bank contains, the more attached the player would feel with their inner child allowing for the formation and strengthening of these bonds to be achieved easier. Profile Extension Exercise seeks to help the player populate their Memory Banks with information and content.

The exercises uses the information stored in the Profile Data in order to select the type of content which it chooses to prompt the player to input. The exercises are also chosen at random, meaning content from all the Memory Bank areas would eventually be populated. Once an exercise is completed, the information gathered from the exercise would be added to the Profile Data ready to be displayed in the Memory Bank. The exercises are made to be external to the game engine. This design decision was made so that the addition and removal of exercises would be easier allowing for future work by other developers. The following are the exercises implemented into the game.

Photo Description

In this exercise, the game searches for any imported photos. If photos are found, then the game picks one at random. The picture is then displayed on the screen and the player is asked to give a description of the photo. Once the description is entered, then this information is added into the Profile Data where it is stored together with the specific photo to be viewed in the Photo Gallery. The purpose behind this exercise is to excite the emotional portion of the player, since the photo would be of significance to the player's childhood, by describing the photo, the player would be inclined to remember stories relating to the photo.

Affirmation Builder

This exercise seeks to motivate the player to add to their affirmation list. Affirmations are a powerful tool to alter a person's emotions. By having more positive affirmations to relate to, the player would be more inclined to think more positively. The exercise brings the player to the Add Affirmation page where the palyer can add a custom affirmation or an existing one from the default affirmation module.

Journal Entry

This exercise prompts the player to add a journal entry which would then be displayed on the main screen of the Memory Bank. Journal Entries is also an effective tool to exciting a person's emotional part of the brain because it involves the person to recall and relive a certain memory. With more Journal Entries, the player would be more attached to their inner child profile.

Music Recollection

In this exercise, the game searches for any imported song. If songs are found, then the game randomly selects one of the songs in the library. The song is then played and the player is asked to type in the song's title and lyrics unless it has already been done. This exercise is to allow the player to familiarize with the details of the song so the player would be able to to just recall the lyrics of the song with ease in case the player decides to sing to provoke positive emotions. Since music is an effective therapeutic tool, it is important that the subject is able to learn the lyrics enough to be able to instantly recall them.

7.7 Secure Self-Attachment Therapy Protocol

One of the most important art of the Secure Self-Attachment Therapy is the strengthening of the subject to inner child bond. The neural connections that are associated with this bond is the foundation to the therapy itself. These exercise help increase the efficiency of the neural connections associated with the communications between the left and right hemispheres of the brain. In this game, these exercises are named "Secure Self-Attachment Therapy Protocols". The aim of these exercises are to promote position emotions while the player maintains a heightened emotional state regarding their inner child.

The protocols uses the stress information found in the game's User Data and selects appropriate exercises for the players. The exercises are categorized into three types; low, medium and high stress level exercises. Depending on the most recent stress level that the player input, the exercises from the corresponding category is picked at random and presented to the player. The exercises are also made to be external to the game engine so that the addition and removal of exercises are made easy. The following are the exercises which are already built into the game.

7.7.1 Low Stress Exercise

Sing Along

This exercise plays a song that the player has imported and asks the player to sing along with the song. It has been shown that singing a song that reminds a person of their childhood or any other songs that promote positive emotions greatly aids the therapeutic process of the therapy.

Affirmation Recitation

This exercise picks a random affirmation from the affirmation list and displays it on the screen. The game then prompts the player to remember and recite the affirmation out loud. It is important that the user is able to remember affirmations that they can relate to in order to promote positive emotions.

7.7.2 Medium Stress Exercise

Music Dance

This exercise plays a song from the Memory Bank and prompts the player to dance along with the song. Dancing and physical movement has proven to be an effective therapy tool and since the player is dancing to a song that he or she finds enjoyable, the player would be more inclined to perform this exercise

Mother's Touch

It has been shown that most mother's touch and handling of their infants has a calming and therapeutic effect. The resulting positive emotions can be seen on the baby's response when relieved by their mothers. Through mirror neurons and humans ability to emphasize, just by observing a mother calming her infant or imitating the actions of soothing an infant has proven to be stress relieving. Hence this exercise displays a picture of a mother calming her infant while the game instructs the player to imagine their inner child at distress and to perform actions on themselves in order to relieve the stress.

7.7.3 High Stress Exercise

Imaginative Play: Stressful Situation

This exercise involves imaginative play from the player. The player is asked to imagine or recall a recent stressful situation. Then the game instructs the player to imagine a method to relieve the stress and remove themselves from the situation. This is a form of a co-construction of a new personal narrative where the player associates new neural paths to the stress inducing networks and effectively reducing the negative effects of the network.

Imaginative Play: Inner Child Struggle

Inefficient neural circuits within a subject's brain can affect their ability to process stressful situations and in turn cause depression or anxiety. This can be due to neural connections relating to insecure attachment during childhood. This exercise is aimed to address this issue. The game instructs the player to imagine or recall a traumatic or stressful situation that happened during the player's childhood. The player imagines their inner child in this situation and describes it through text input. Then the game instructs the player to imagine themselves as the adult self entering this situation and removing their distressed inner child from the situation. This form of co-construction of a new narratives helps form new neural connections and through repetition, these healthy connections could in theory override the old unhealthy ones if strong enough.

Chapter 8

Evaluation

8.1 Game Evaluation

Upon the completion, the game was was ready to be evaluated. Ideally, the game would be clinically tested in order to evaluate the game's effectiveness in applying Secure Self-Attachment Therapy however this would have been out of the scale of this project. To compensate for this limitation, the game was sent to a number of human volunteers ranging from subjects who have been through different types of psychotherapy as well as subject's who were new to the concept of psychotherapy. The game was also sent to Dr. Dean Petters, a computer scientist and a chartered psychologist who specializes in attachment theory to be reviewed and analysed.

8.1.1 User Trials

The feedbacks that were obtained by the variety of volunteers were mostly positive. All of the the subjects complimented the game's visual aspect as well as the game's ability to convey the therapy information through the use of slides, one volunteer stated that the information slides were "informative, interesting and pleasing to the eyes". A volunteer enjoyed the "user friendly" aspect of the game and another user admired the details of the game. For example the validation of the number of the age in the journal exercises.

However there were some criticisms for the game itself. Some volunteers were confused with the instructions on how to import songs or photos and also the general instructions to proceed through the slides. These constructive criticisms were used to further improve the game. For example, for the initial release of the game, the instructions were included as a "ReadMe" text file that was included in the game and provided in the Appendix of this report. However, it was noticed that not all users would be motivated to read this document. To solve this problem, the instructions were turned into informational slides and included as part of the introduction. This means that in order to proceed through the game, the player would have to learn the instruction set of the game first. It was also commented that the exercise library is rather limiting and in cases where players do not have much contents in their Memory Banks, some exercises repeat themselves. In order to solve this problem more exercises can be entered into the game for future work.

The general feedbacks obtained by the volunteers were mostly concerned of the game aspect of the program and not the the therapeutic aspect of the game. For that portion of the game to be tested thoroughly, the game would have to be sent for clinical trials.

8.2 Comparison as a Computerized Psychotherapy

8.2.1 Beating the Blues

This project draws many inspirations from Beating the Blues. This was mainly implemented as the informational slides found in Phase 1 of the game. After testing Beating the Blues, I was fascinated by how efficiently the tool was able to convey the lessons and informations that was needed for each session. The quiz portion of Phase 1 was also inspired by Beating the Blues.

In Beating the Blues, the player is asked to perform 8 sessions. It follows a linear design where the player learns the Cognitive Behavioural Therapy techniques and information through the progression of these sessions. Once a session is completed, the player would progress and be unable to return to any previous sessions. However, they are able to view their answers to any questions asked in earlier sessions. The Secure Self-Attachment Therapy game takes a different approach to the player's progress. The player is able to cycle through different phases of the game at their own will and perform activities which they find more effective. This approach can potentially make the game feel more personal and customizable allowing players to learn the therapy at their own pace and select their own course.

Accessibility is important a psychotherapy tool. Beating the Blues is a web based application and requires log in credentials in order to retrieve account details. This means that Beating the Blue can be accessed through any computer or mobile device that has access to the internet. However, Secure Self-Attachment Therapy game is currently only available on the player's local computer. This can be solved through future development explained in the later chapter can make the game more portable and accessible.

8.2.2 SPARX

SPARX is a Cognitive Behavioural Therapy tool which is packaged as a 3D interactive adventure game. Through the advancement of the game, the player learns the therapeutic techniques behind the Cognitive Behavioural Therapy. The main difference between SPARX and the Secure Self-Attachment Therapy game are the visual graphics. SPARX is targeted for adolescence who suffers from depression or anxiety, hence the graphics and 3D game play would attract this audience base. However the current version of the Secure Self-Attachment Therapy game is targeted at a more mature audience so there is less need for a "3D game" experience. The important feature that stays true to SPARX is that the Secure Self-Attachment Therapy game teaches the therapeutic techniques as well as instructs the user to perform actions or exercises that promote positive emotions or reinforce the techniques learnt.

Similar to Beating the Blues, SPARX has a linear design where players visit different 'provinces' in sequential order. In these provinces, the players are faced with a themed problem where through the information of therapeutic techniques and interactive game play the player progresses through. The player would then be unable to revisit provinces which may be a bit of a disadvantage over the Secure Self-Attachment Therapy game where players are able to alternate between phases. However, the linear aspect of these therapy tools mean that the user would be guaranteed to have learnt or was exposed to all the therapeutic aspect of the game.

Accessibility is similar to the Secure Self-Attachment game where it is only available on the player's local computer. However, SPARX requires the user to install the game into the computer whereas the Secure Self-Attachment game can be run directly from the game directory once the user has obtained it.

8.3 Evaluation of Framework

In this project, the game engine Ren'Py was used to build and script the game. This game engine was originally designed to build story telling applications mainly consisting of images and text. However since it can also run native Python codes, features that would be limited by the game engine can be built directly into it.

The focus on story telling in the game engine meant that the construction of the informational slides and generally Phase 1 of the game was of relative ease with built in functions such as transitions and overall game flow scripting. However, these benefits also became limitations for when game menus were in need. Since the game engine was built for linear use, the ability to switch between phases while retaining user information was initially challenging. Also, the game engine was built so that the media displayed in the game are assumed to be provided with the construction of the game so having the ability to add custom songs and photos were also unavailable. To solve this problem, a python program was built in order to locate custom media and add it into the game directory.

Overall, Ren'Py became an effective tool in creating the Secure Self-Attachment Therapy game due to many built it in features such as variable management, saving and loading features and general game flow features. The ability to run external python code was valuable as it allowed custom features throughout the game to be added in.

Chapter 9

Conclusion

9.1 Secure Self-Attachment Therapy

Secure Self-Attachment Therapy game is a computerized psychotherapeutic tool which teaches users to learn and perform therapeutic exercises relating to Secure Self-Attachment Therapy and Attachment Theory. The game is split into 3 phases which reflects the therapy process which it is based on. Phase 1 focuses on the informational aspect of the game and seeks to excite the player's cognition. Phase 2 consists of a Memory Bank where the player is able to construct their profile relating to their inner child by populating it with contents such as journal entries, music, photos and affirmation. Phase 3 is the exercise portion of the game where players are provided with exercises which aim to help form and strengthen the neural connections relating to secure attachment.

The design of the game was made to be simple and minimalistic which has been noted by trial volunteers. This decision was made so that the game would not be distracting so that the player can focus on the therapy aspect of the game. It was also decided that customizability was important for this therapy since the basis of which the therapy relies on is the bond between the player and their inner self or child. The Memory Bank and the personalized exercises create this sense of customizability so that the player can have a strong bond with their inner child while playing the game. Also the game was designed in a way where future development, features or exercises can be added or removed with ease.

Lastly for this project, an A.I. Guide was developed and implemented into the game as a guide to the course of exercises to perform. The A.I. Guide emulates human learning behaviours hence with this guide enabled, the player may be more inclined to perform the exercises that it chooses. However models driving these intelligent agents are far from being as complex as a physical human brain hence the players are presented with the option to enable or disable this feature.

To conclude the Secure Self-Attachment Therapy game provides a tool where users can learn and perform therapeutic techniques in the comforts of the user's home. It provides a platform where users can learn to self reflect and to explore therapy on their own.

9.2 Computerized Psychotherapy

As mentioned in earlier chapters, the main drawback for computerized psychotherapies are that computers are more from sophisticated enough to emulate the empathy and emotional capabilities that human psychotherapists has. However the use of computing resources seem to be drawing away from attempting to replace human therapists but more is used in the development in tools that teach psychotherapeutic techniques. Since the player is both the therapist and patient in the

Secure Self-Attachment Therapy game, it has great potential as an anchor in the development of computerized tools in the field of psychotherapy.

9.3 Future Work

There are many areas for future developments in the game. As a therapeutic tool, adding Cognitive Behavioural Therapy concepts, information and techniques would increase the therapeutic effects of the game. Since Cognitive Behavioural Therapy focuses on teaching the user how to self reflect and analysis their thoughts, by achieving this technique the user would be able to apply this analytical state of mind to the techniques relating to Secure Self-Attachment Therapy. Both therapies would compliment each other's effects and hopefully the user would achieve a more effective result from it.

Another area where future work can be applied would be by adding more features to the Memory Bank in order to increase the customizability of the game. Examples would be voice journal entries or text to speech functionalities so that affirmations could be read aloud by the computer. Another feature to add customizability would be to allow the player to create an avatar which represents their inner child. This would involve the player uploading a picture of them as a child and the tool would produce a child model and render it with the information gathered from the photograph itself.

Lastly the A.I. Guide provides a model of an intelligent agent with learning behaviours. However it is far from being sophisticated enough to model the complex human brain. Future work into developing more accurate models would benefit the tool. This could be through the development of a more accurate intelligent agent for guiding purposes but also to provide a better understanding to the workings of the human mind itself.

Bibliography

[1] World Health Organization. The World Health Report. `http://www.who.int/whr/2001/media_centre/en/index.html`, June 2013.

[2] Paul D MacLean. *The Triune brain in Evolution: Role in Paleocerebral Functions*. Springer, 1990.

[3] Giacomo Rizzolatti and Laila Craighero. The mirror-neuron system. *Annu. Rev. Neurosci.*, 27:169–192, 2004.

[4] Inge Bretherton. The origins of attachment theory: John bowlby and mary ainsworth. *Developmental Psychology*, 28(5):759, 1992.

[5] John Bowlby. Child care and the growth of love. *London 1953*, 1953.

[6] H Rudolph Schaffer. *Introducing Child Psychology*. Wiley-Blackwell, 2003.

[7] Howard Steele, Miriam Steele, and Peter Fonagy. Associations among attachment classifications of mothers, fathers, and their infants. *Child Development*, 67(2):541–555, 1996.

[8] Dorota Iwaniec. *The Emotionally Abused and Neglected Child: Identification, Assessment and Intervention: A Practice Handbook*. Wiley.com, 2006.

[9] Richard D Gross and Paul Humphreys. *Psychology: The Science of Mind and Behaviour*. Hodder & Stoughton London, 1992.

[10] Mary D Salter Ainsworth, Mary C Blehar, Everett Waters, and Sally Wall. *Patterns of Attachment: A Psychological Study of the Strange Situation.* Lawrence Erlbaum, 1978.

[11] Mary Main and Erik Hesse. Parents' unresolved traumatic experiences are related to infant disorganized attachment status: Is frightened and/or frightening parental behavior the linking mechanism? 1990.

[12] Louis Cozolino. *The Neuroscience of Human Relationships: Attachment and the Developing Social Brain*. WW Norton & Co, 2006.

[13] Michael F Basch and Carol G Basch. *Understanding Psychotherapy: The Science Behind the Art*. Basic Books, 1990.

[14] Abbas Edalat and Federico Mancinelli. Strong attractors of hopfield neural networks to model attachment types and behavioural patterns. In *Proceedings of International Joint Conference on Neural Networks (IJCNN)*, 2013.

[15] Lloyd S Shapley. Stochastic games. *Proceedings of the National Academy of Sciences of the United States of America*, 39(10):1095, 1953.

[16] Xavier Vives. Nash equilibrium with strategic complementarities. *Journal of Mathematical Economics*, 19(3):305–321, 1990.

[17] Sandip Sen, Stephane Airiau, and Rajatish Mukherjee. Towards a pareto-optimal solution in general-sum games. In *Proceedings of the Second International Joint Conference on Autonomous Agents and Multiagent Systems*, pages 153–160. ACM, 2003.

[18] Alberti L. Chan R. Mathematical Models of Mother/Child Attachment. http://www.math.toronto.edu/mpugh/Prints/MotherChild-FMIPW-Report-1.pdf, June 2013.

[19] Ronald A Howard. Dynamic programming and markov processes. 1960.

[20] Richard S Sutton and Andrew G Barto. *Reinforcement Learning: An Introduction*, volume 1. Cambridge Univ Press, 1998.

[21] Leslie Pack Kaelbling, Michael L Littman, and Andrew W Moore. Reinforcement learning: A survey. *arXiv preprint cs/9605103*, 1996.

[22] Christopher JCH Watkins and Peter Dayan. Q-learning. *Machine Learning*, 8(3-4):279–292, 1992.

[23] Ido Erev and Alvin E Roth. Predicting how people play games: Reinforcement learning in experimental games with unique, mixed strategy equilibria. *American Economic Review*, pages 848–881, 1998.

[24] Christopher John Cornish Hellaby Watkins. *Learning from Delayed Rewards*. PhD thesis, University of Cambridge, 1989.

[25] Junling Hu and Michael P Wellman. Nash q-learning for general-sum stochastic games. *The Journal of Machine Learning Research*, 4:1039–1069, 2003.

[26] David Cittern and Abbas Edalat. Models of child-parent interaction in game theory. Master's thesis, Imperial College London, 2011.

[27] Cai Zhou. Solving stochastic games for child-parent interaction. Master's thesis, Imperial College London, 2012.

[28] Beating the Blues. Beating the Blues: Cognitive Behavioural Therapy. http://www.beatingtheblues.co.uk, June 2013.

[29] SPARX. SPARX. https://www.sparx.org.nz, June 2013.

[30] Ren'Py. Open Source Python Framework for Creating Life Simulation Games. http://www.renpy.org, June 2013.

Appendix A

User Guide

Secure Self-Attachment Therapy

Game Background

Secure Self-Attachment Therapy is a therapeutic game which uses the principles from Secure Self-Attachment Therapy developed by Professor Abbas Edalat as well as principle studies and concepts of Attachment Theory. It seeks to help players to form a secure attachment in order to remedy any negative consequences and problems rooting from a lack of secure attachment during the player's childhood. The game has three sections and the players are required to alternate between them.

Section 1

The first part of the game is to gather information regarding the game and the scientific principles behind it. It is important to you complete this section and read all the information that it contains. To progress through this section, the player can simply left click on the images to proceed. This section must be completed for first time users and after the section can always be returned by clicking on the 'Information' button in the section 2 menu.

Section 2

The second part of the game is concerned with exciting you emotionally. This section represents the player's inner child's profile. It acts as a memory bank where the player can import photos, music and also add affirmations and journal entries for viewing and interactive purposes. It is important that the player imports and adds as much information and media content as he or she can, in order to fully maximise the effectiveness of the game.

In order to import Photos, in the Secure Self-Attachment Folder, there is a 'Photos' Folder. Drag images in this folder to import them into the game.

In order to import Music, in the Secure Self-Attachment Folder, there is a 'Music' Folder. Drag music files or songs into this folder to import them into the game.

Section 3

Finally section 3 of the game is concerned about the exercises and protocols that are behind the Secure Self-Attachment Therapy. Once entered, the player will be prompt to play a set of 5 rounds of mini-games where the players can win points. The player can choose between two types of exercises, profile extension exercises and secure self attachment protocols. Profile extensions are exercises to expand your memory bank and secure self-attachment protocols are exercises that encourage secure neural connections. If you would like the game to decide which exercise to pick from, at the Section 3 Menu you can enable the Artificial Guide by clicking on the 'AI Guide' button.

Overall

The more frequent you play the game will increase the effectiveness of the therapy. Also, remember that the exercises that are in this game does not only work within the game, try to use the techniques in real life. Hope you will enjoy playing Secure Self-Attachment Therapy!

Basic Help

To advance through the game, `left-click` or press the `space` or `enter` keys. When at a menu, `left-click` to make a choice, or use the arrow keys to select a choice and `enter` to activate it.

Game Menu

When playing a game, `right-click` or press the `escape` key to enter the game menu. The game menu gives the following choices:

Return
Returns to the game.
Save Game
Allows you to save a game by clicking on a save slot.
Load Game
Allows you to load a game by clicking on a save slot. Clicking on "Auto" accesses the automatic save slots.
Preferences
Changes the game preferences (options/configuration):
Display
Switches between fullscreen and windowed mode.
Transitions
Controls the display of transitions between game screens.
Text Speed
Controls the rate at which text displays. The further to the right this slider is, the faster the text will display. All the way to the right causes text to be shown instantly.
Joystick
Lets you control the game using a joystick.
Skip
Chooses between skipping messages that have been already seen (in any play through the game), and skipping all messages.
Begin Skipping
Returns to the game, while skipping.
After Choices
Controls if skipping stops upon reaching a menu.
Auto-Forward Time
Controls automatic advance. The further to the left this slider is, the shorter the amount of time before the game advances. All the way to the right means text will never auto-forward.
Music, Sound, and Voice Volume
Controls the volume of the Music, Sound effect, and Voice channels, respectively. The further to the right these are, the louder the volume.
Main Menu
Returns to the main menu, ending the current game.
Help
Shows this help screen.
Quit
Exits the game; the game will be closed and ended.

Section 2 Menu (Memory Bank)

Information
Returns to Section 1 (Information).
Back
Returns to the Main Menu.
Continue
Proceeds to Section 3 (Game).

Section 3 Menu (Game)

Back
Returns to the Section 2 Menu (Memory Bank).
View Scores
Shows the history of scores.
AI Guide
Toggles On/Off depending on whether the Artificial Guide is wanted.

Play
Proceeds to pick and execute a Mini-Game

Key and Mouse Bindings

Left-click, Enter
Advances through the game, activates menu choices, buttons, and sliders.
Space
Advances through the game, but does not activate choices.
Arrow Keys
Selects menu choices, buttons, and sliders.
Ctrl
Causes skipping to occur while the ctrl key is held down.
Tab
Toggles skipping, causing it to occur until tab is pressed again.
Mousewheel-Up, PageUp
Causes rollback to occur. Rollback reverses the game back in time, showing prior text and even allowing menu choices to be changed.
Mousewheel-Down, PageDown
Causes rollforward to occur, cancelling out a previous rollback.
Right-click, Escape
Enters the game menu. When in the game menu, returns to the game.
Middle-click, H
Hides the text window and other transient displays.
F
Toggles fullscreen mode
S
Takes a screenshot, saving it in a file named screenshotxxxx.png, where xxxx is a serial number.
Alt-M, Command-H
Hides (iconifies) the window.
Alt-F4, Command-Q
Quits the game.
Delete
When a save slot is selected, deletes that save slot.

Legal Notice

Appendix B

Beck's Depression Inventory

Beck's Depression Inventory

This depression inventory can be self-scored. The scoring scale is at the end of the questionnaire.

1.
- 0 I do not feel sad.
- 1 I feel sad
- 2 I am sad all the time and I can't snap out of it.
- 3 I am so sad and unhappy that I can't stand it.

2.
- 0 I am not particularly discouraged about the future.
- 1 I feel discouraged about the future.
- 2 I feel I have nothing to look forward to.
- 3 I feel the future is hopeless and that things cannot improve.

3.
- 0 I do not feel like a failure.
- 1 I feel I have failed more than the average person.
- 2 As I look back on my life, all I can see is a lot of failures.
- 3 I feel I am a complete failure as a person.

4.
- 0 I get as much satisfaction out of things as I used to.
- 1 I don't enjoy things the way I used to.
- 2 I don't get real satisfaction out of anything anymore.
- 3 I am dissatisfied or bored with everything.

5.
- 0 I don't feel particularly guilty
- 1 I feel guilty a good part of the time.
- 2 I feel quite guilty most of the time.
- 3 I feel guilty all of the time.

6.
- 0 I don't feel I am being punished.
- 1 I feel I may be punished.
- 2 I expect to be punished.
- 3 I feel I am being punished.

7.
- 0 I don't feel disappointed in myself.
- 1 I am disappointed in myself.
- 2 I am disgusted with myself.
- 3 I hate myself.

8.
- 0 I don't feel I am any worse than anybody else.
- 1 I am critical of myself for my weaknesses or mistakes.
- 2 I blame myself all the time for my faults.
- 3 I blame myself for everything bad that happens.

9.
- 0 I don't have any thoughts of killing myself.
- 1 I have thoughts of killing myself, but I would not carry them out.
- 2 I would like to kill myself.
- 3 I would kill myself if I had the chance.

10.
- 0 I don't cry any more than usual.
- 1 I cry more now than I used to.
- 2 I cry all the time now.
- 3 I used to be able to cry, but now I can't cry even though I want to.

11.

0 I am no more irritated by things than I ever was.
1 I am slightly more irritated now than usual.
2 I am quite annoyed or irritated a good deal of the time.
3 I feel irritated all the time.

12.

0 I have not lost interest in other people.
1 I am less interested in other people than I used to be.
2 I have lost most of my interest in other people.
3 I have lost all of my interest in other people.

13.

0 I make decisions about as well as I ever could.
1 I put off making decisions more than I used to.
2 I have greater difficulty in making decisions more than I used to.
3 I can't make decisions at all anymore.

14.

0 I don't feel that I look any worse than I used to.
1 I am worried that I am looking old or unattractive.
2 I feel there are permanent changes in my appearance that make me look unattractive
3 I believe that I look ugly.

15.

0 I can work about as well as before.
1 It takes an extra effort to get started at doing something.
2 I have to push myself very hard to do anything.
3 I can't do any work at all.

16.

0 I can sleep as well as usual.
1 I don't sleep as well as I used to.
2 I wake up 1-2 hours earlier than usual and find it hard to get back to sleep.
3 I wake up several hours earlier than I used to and cannot get back to sleep.

17.

0 I don't get more tired than usual.
1 I get tired more easily than I used to.
2 I get tired from doing almost anything.
3 I am too tired to do anything.

18.

0 My appetite is no worse than usual.
1 My appetite is not as good as it used to be.
2 My appetite is much worse now.
3 I have no appetite at all anymore.

19.

0 I haven't lost much weight, if any, lately.
1 I have lost more than five pounds.
2 I have lost more than ten pounds.
3 I have lost more than fifteen pounds.

20.

0 I am no more worried about my health than usual.
1 I am worried about physical problems like aches, pains, upset stomach, or constipation.
2 I am very worried about physical problems and it's hard to think of much else.
3 I am so worried about my physical problems that I cannot think of anything else.

21.

0 I have not noticed any recent change in my interest in sex.
1 I am less interested in sex than I used to be.
2 I have almost no interest in sex.
3 I have lost interest in sex completely.

INTERPRETING THE BECK DEPRESSION INVENTORY

Now that you have completed the questionnaire, add up the score for each of the twenty-one questions by counting the number to the right of each question you marked. The highest possible total for the whole test would be sixty-three. This would mean you circled number three on all twenty-one questions. Since the lowest possible score for each question is zero, the lowest possible score for the test would be zero. This would mean you circles zero on each question. You can evaluate your depression according to the Table below.

Total Score_____Levels of Depression

1-10_____These ups and downs are considered normal
11-16_____ Mild mood disturbance
17-20_____Borderline clinical depression
21-30_____Moderate depression
31-40_____Severe depression
over 40_____Extreme depression

A PERSISTENT SCORE OF 17 OR ABOVE INDICATES THAT YOU MAY NEED MEDICAL TREATMENT. IF YOU HAVE ANY CARDIAC CONCERNS, PLEASE CONTACT CARDIOVASCULAR INTERVENTIONS, P.A. at 407-894-4880

Appendix C

Beck's Anxiety Inventory

Beck Anxiety Inventory

Below is a list of common symptoms of anxiety. Please carefully read each item in the list. Indicate how much you have been bothered by that symptom during the past month, including today, by circling the number in the corresponding space in the column next to each symptom.

	Not At All	Mildly but it didn't bother me much.	Moderately - it wasn't pleasant at times	Severely – it bothered me a lot
Numbness or tingling	0	1	2	3
Feeling hot	0	1	2	3
Wobbliness in legs	0	1	2	3
Unable to relax	0	1	2	3
Fear of worst happening	0	1	2	3
Dizzy or lightheaded	0	1	2	3
Heart pounding/racing	0	1	2	3
Unsteady	0	1	2	3
Terrified or afraid	0	1	2	3
Nervous	0	1	2	3
Feeling of choking	0	1	2	3
Hands trembling	0	1	2	3
Shaky / unsteady	0	1	2	3
Fear of losing control	0	1	2	3
Difficulty in breathing	0	1	2	3
Fear of dying	0	1	2	3
Scared	0	1	2	3
Indigestion	0	1	2	3
Faint / lightheaded	0	1	2	3
Face flushed	0	1	2	3
Hot/cold sweats	0	1	2	3
Column Sum				

Scoring - Sum each column. Then sum the column totals to achieve a grand score. Write that score here _____ .

Interpretation

A grand sum between **0 – 21** indicates very low anxiety. That is usually a good thing. However, it is possible that you might be unrealistic in either your assessment which would be denial or that you have learned to "mask" the symptoms commonly associated with anxiety. Too little "anxiety" could indicate that you are detached from yourself, others, or your environment.

A grand sum between **22 – 35** indicates moderate anxiety. Your body is trying to tell you something. Look for patterns as to when and why you experience the symptoms described above. For example, if it occurs prior to public speaking and your job requires a lot of presentations you may want to find ways to calm yourself before speaking or let others do some of the presentations. You may have some conflict issues that need to be resolved. Clearly, it is not "panic" time but you want to find ways to manage the stress you feel.

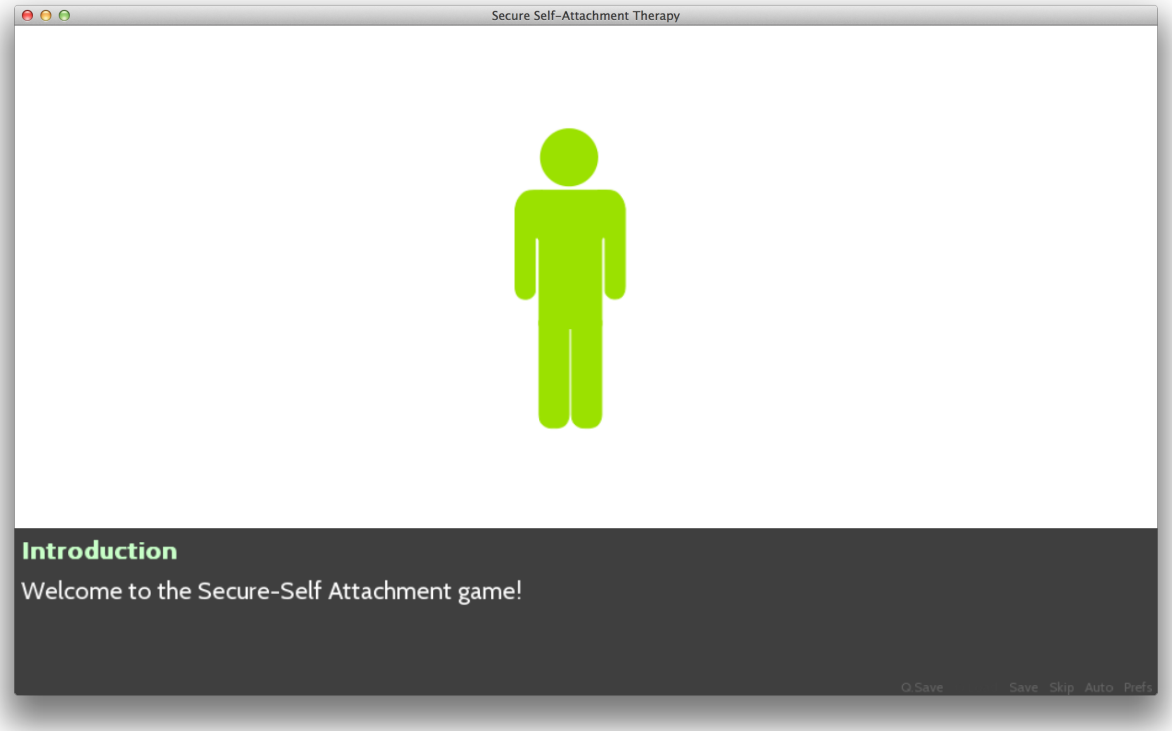
A grand sum that **exceeds 36** is a potential cause for concern. Again, look for patterns or times when you tend to feel the symptoms you have circled. Persistent and high anxiety is not a sign of personal weakness or failure. It is, however, something that needs to be proactively treated or there could be significant impacts to you mentally and physically. You may want to consult a counselor if the feelings persist.

Appendix D

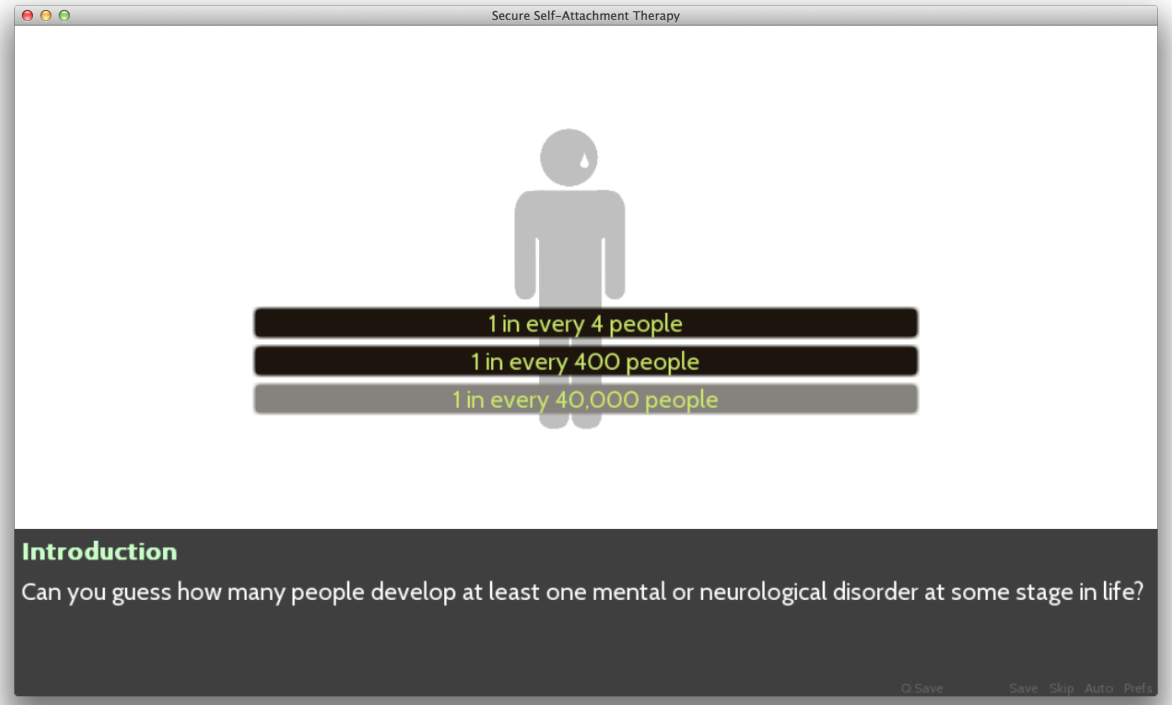
User Scenario

In this chapter, a user scenario is given. The player 'Charles' is followed as he plays the game for the first time. After downloading the game, Charles opens the game directory and double clicks on the "Secure Self-Attachment Therapy.exe". A game window pops up and shows them main menu of the game.

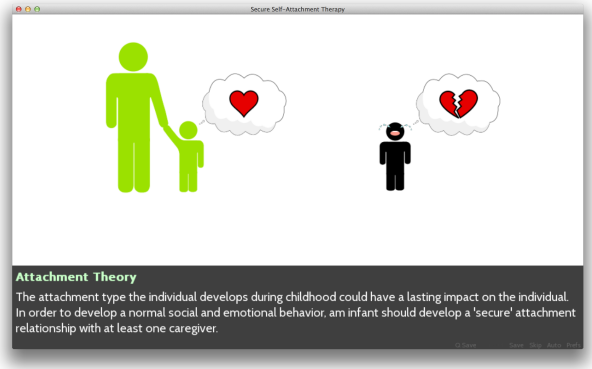
Charles clicks on 'Start Game' and is presented with the welcome page of the game.

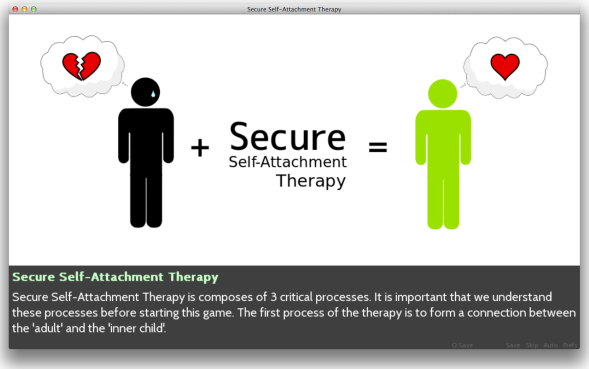


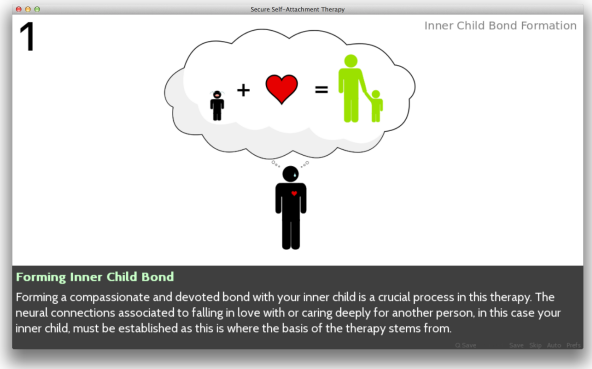
Charles answers the quiz that is provided in the informational slides.



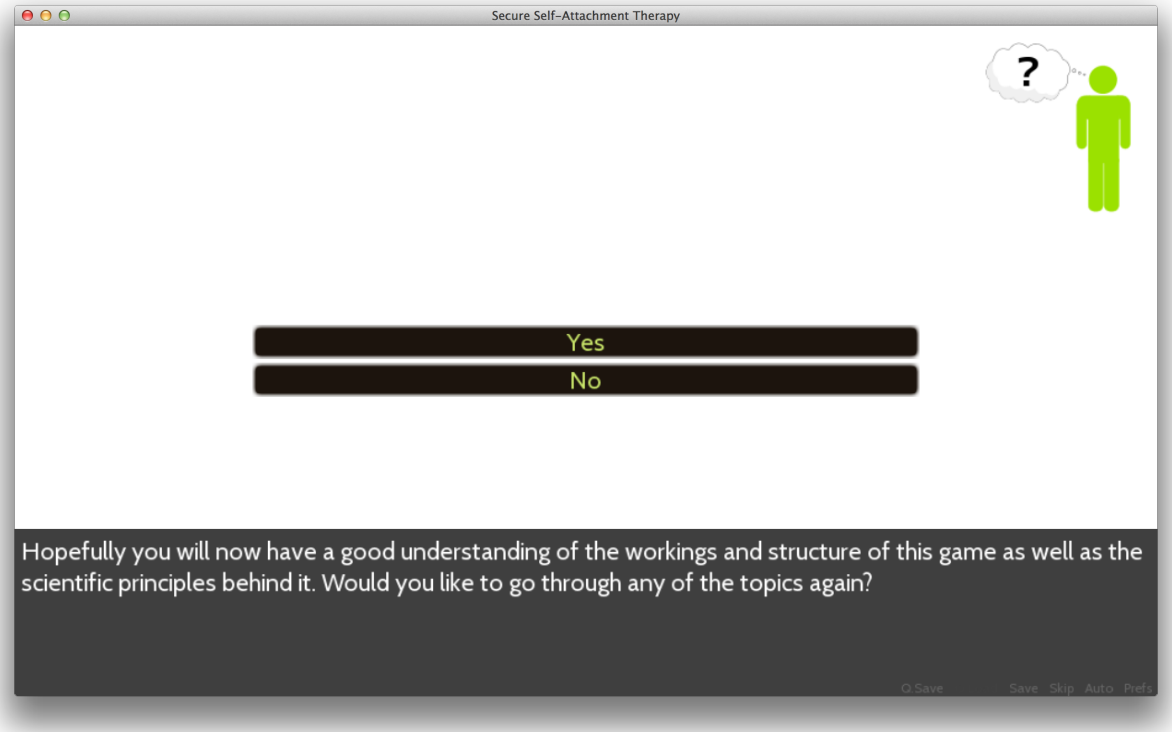
Charles progresses through all the slides and goes through every topic.





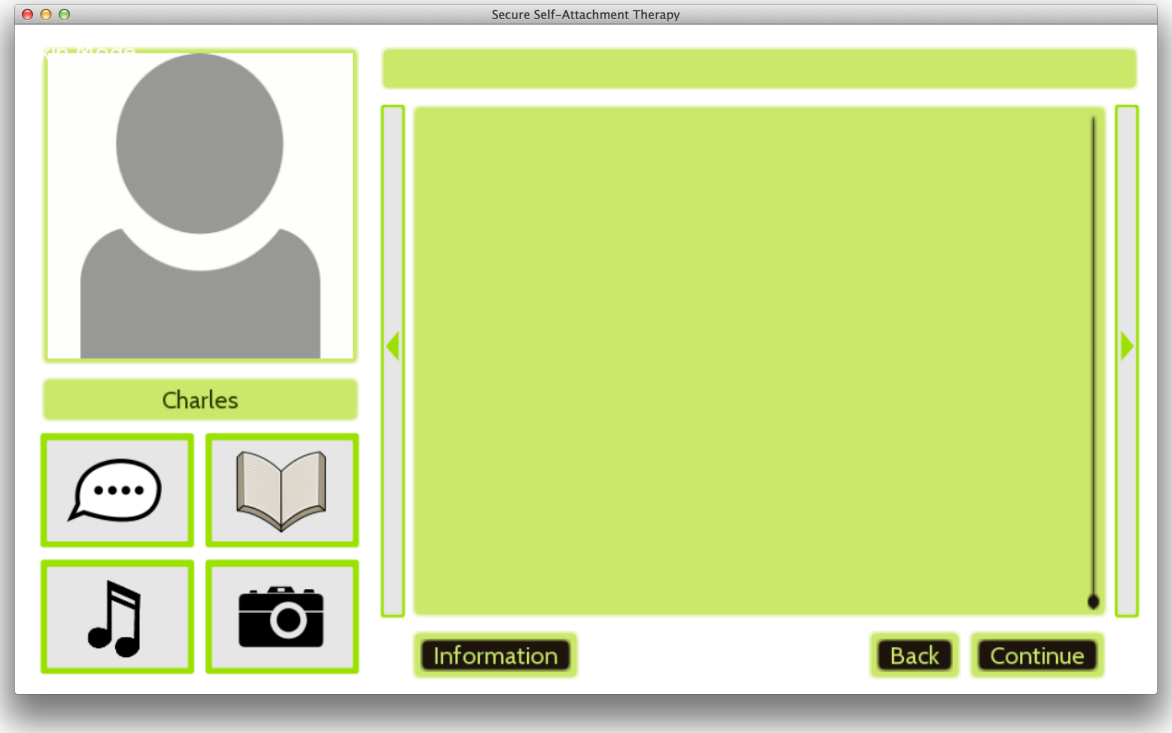


With full understanding of the therapy tool, Charles decides to progess and selects ‘No’.

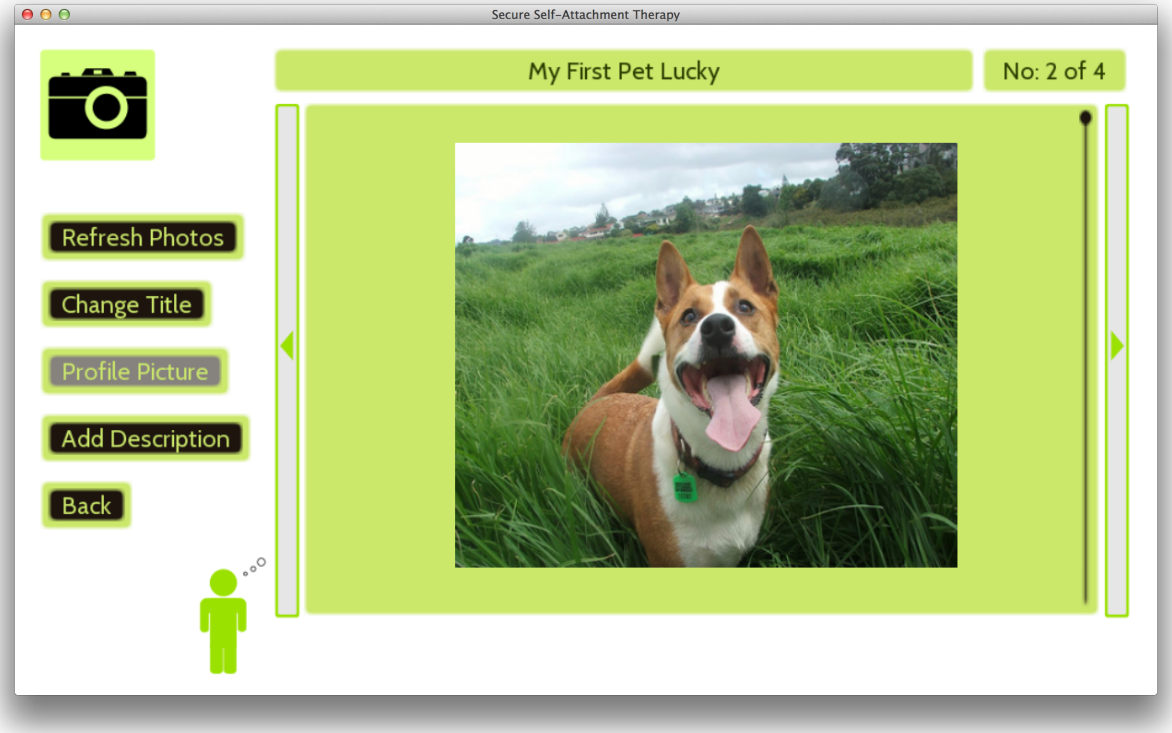


Charles enters his name in the text field and presses ‘Enter’.

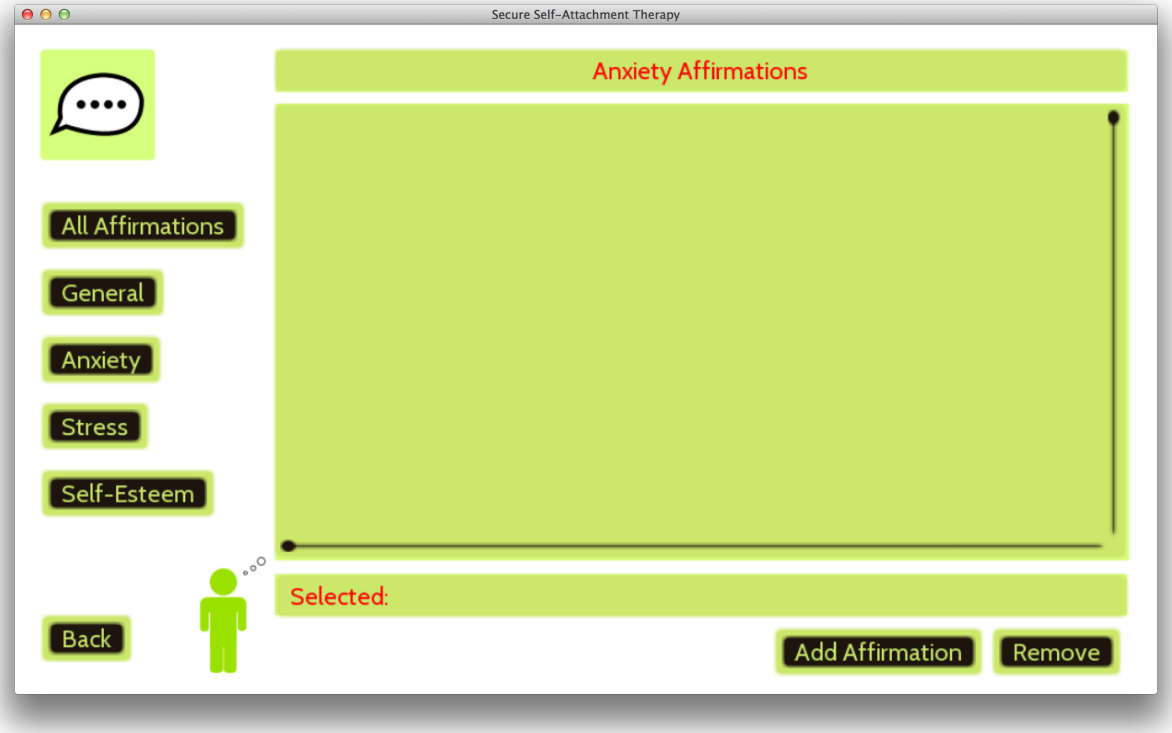
Charles is presented with an empty Memory Bank. He has prepared photos in his computer and he drags the photos into the 'Photos' directory in the game directory. He then proceeds to the Photo Gallery by clicking on the camera.



He cycles through his photos and stops on the one with his dog. He clicks on "Change Title" and types in "My First Pet Lucky" to give the photo a title. He then cycles through to his baby photo and clicks on 'Profile Picture' to set it to his profile picture. The baby photo is his favourite photo of himself.



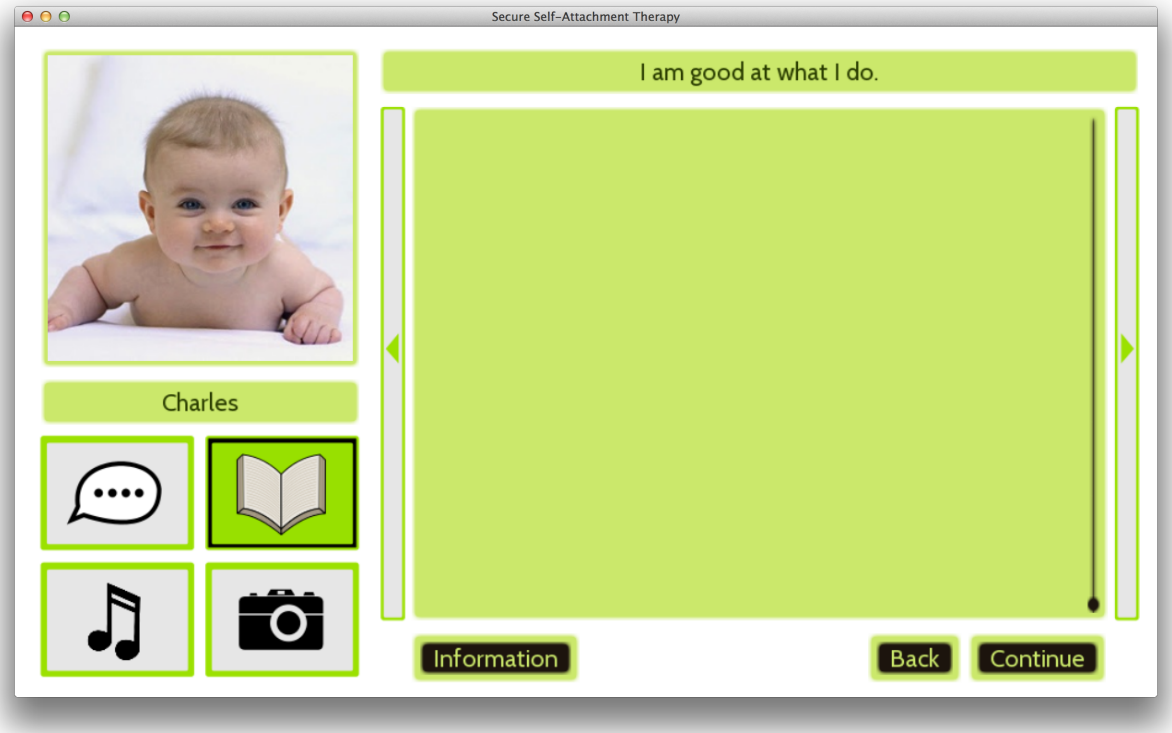
Charles presses 'Back' to return to the Memory Bank and decides to add an affirmation so he proceeds to click on the 'Affirmation' visual button. He is taken to the affirmation page.



Charles clicks on "Add Affirmation" and is presented with two choices; "Add Existing Affirmation" or "Add Custom Affirmation". He had a phrase stuck in his head all day so he decides to add a custom affirmation.

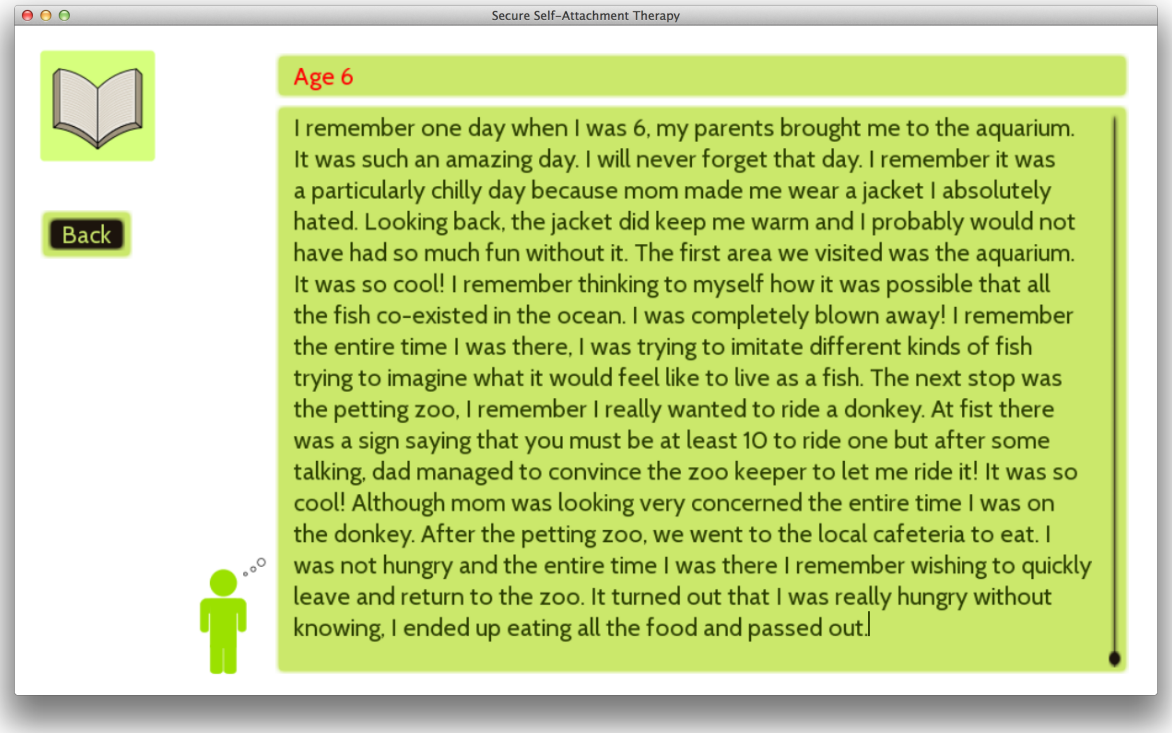
Charles is asked to input his affirmation so he proceeds to type in "I am good at what I do." and presses 'Enter' to confirm.

Charles is returned to the Memory Bank where he observes that his profile picture has been changed and his custom affirmation is presented on the screen. Charles suddenly remembers a childhood story and wants to record it so he proceeds to the Journal Entry by clicking on the journal visual button.



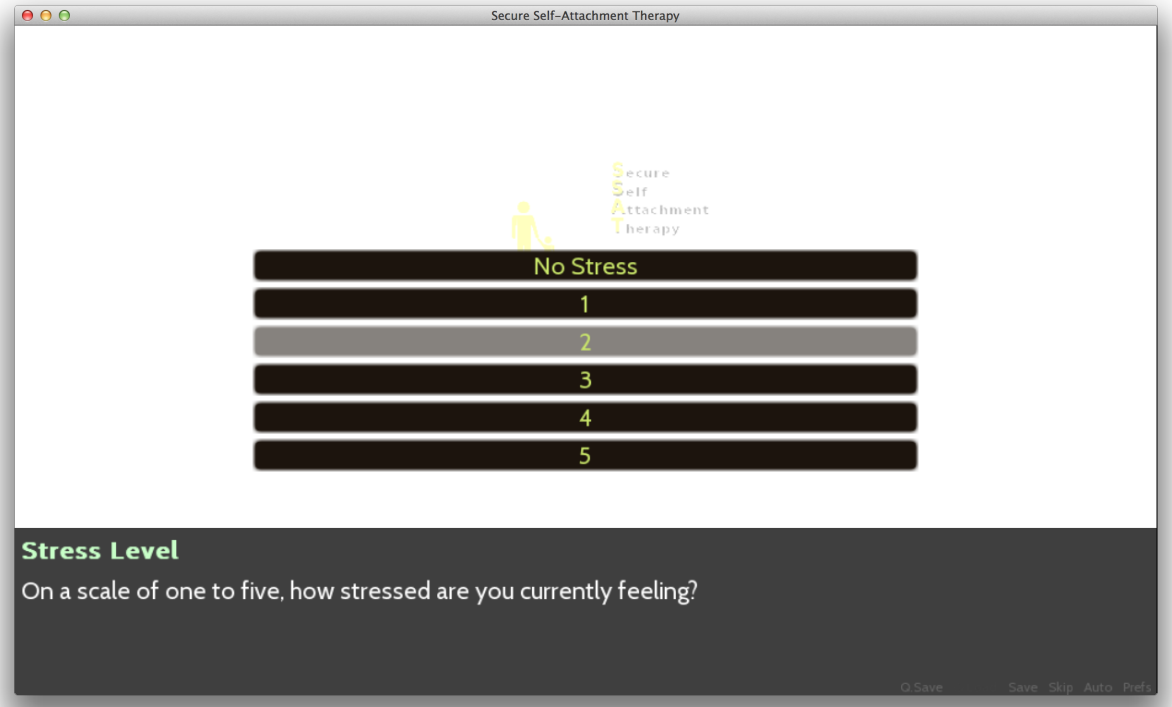
He proceeds to type in the age he was when the story happened, he vaguely remembers that he was 6 so he types it in and hits 'Enter' to confirm.

He then types in the story in the text box provided and tries to remember as much detail as possible. Upon completion, Charles simply pressed 'Enter'.

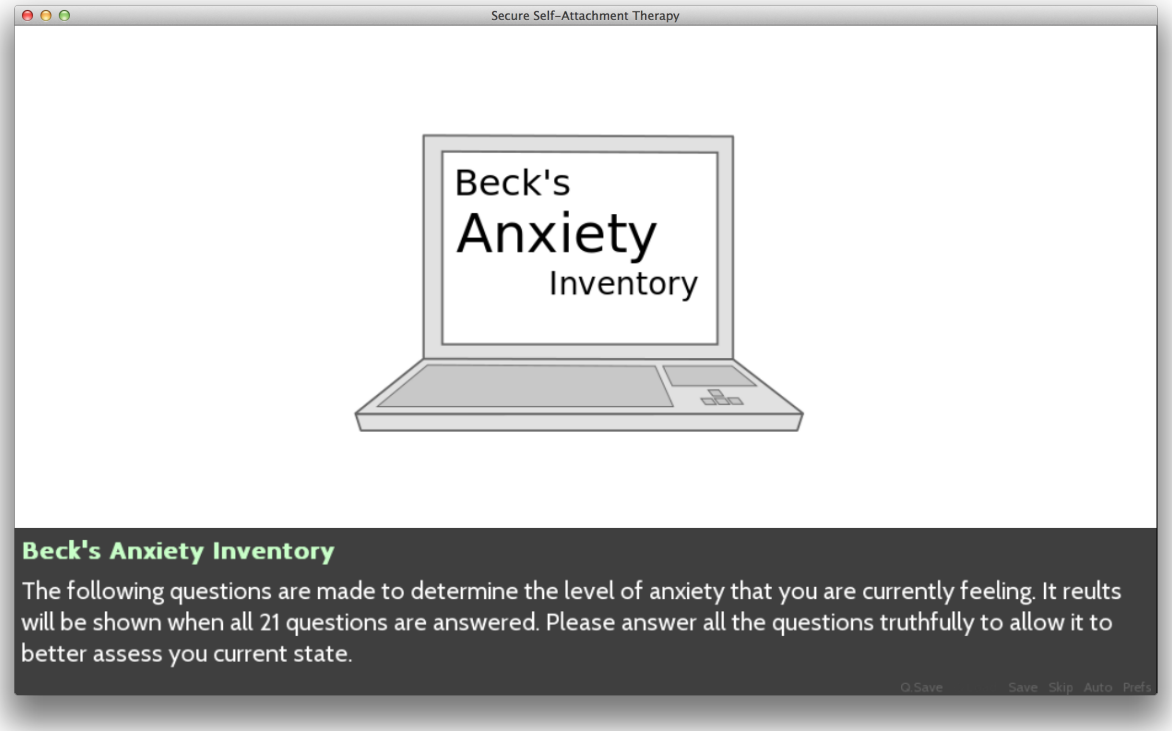


Charles was then returned to the Memory Bank where he notices that his story is now appearing on the main screen. He reads the story back to himself again to recall the memory once more. Charles feels ready to progress so he clicks on 'Continue' to progress to the next phase of the game.

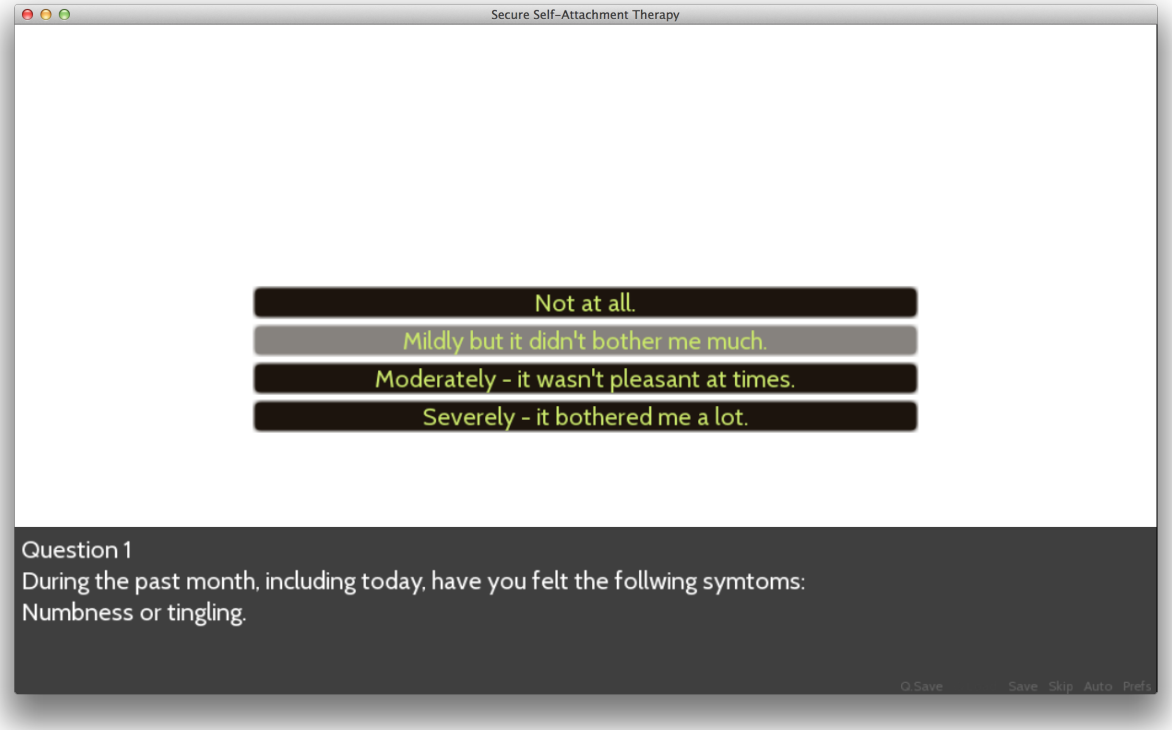
After an introduction to this phase of the game, Charles is asked to select the level of stress he was feeling. He did not particularly feel that stress on the day so he selects '2'.



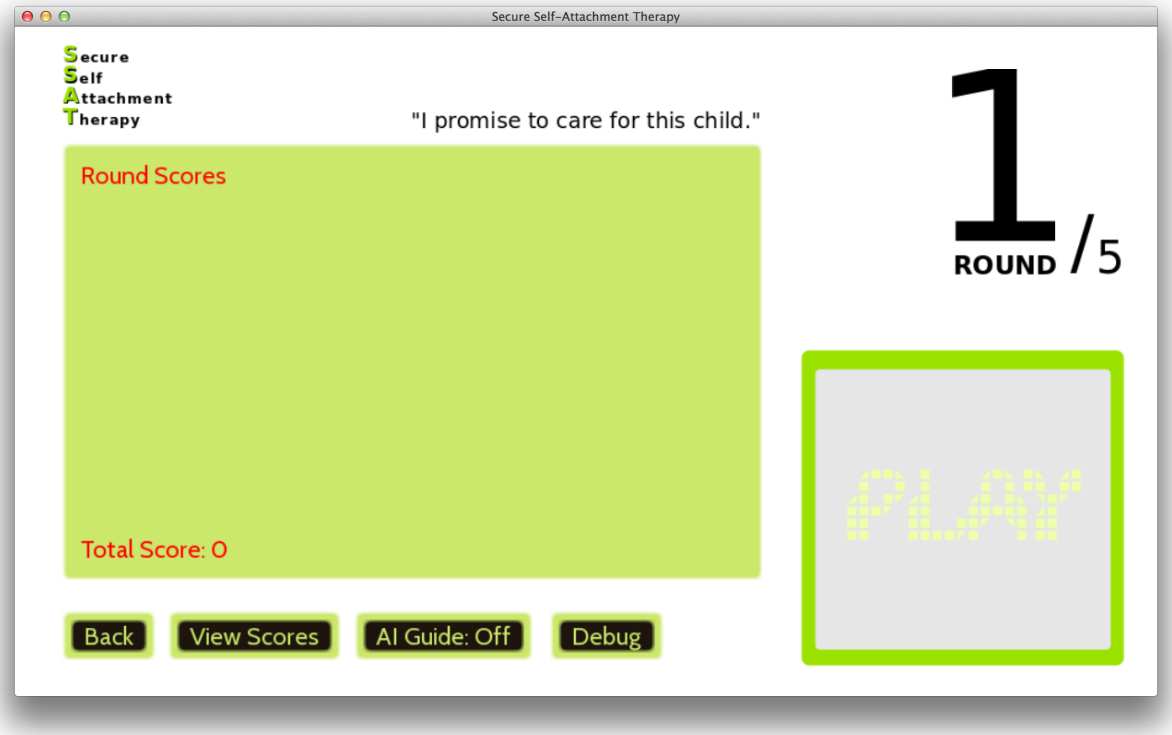
The game then selects questions from Beck's Anxiety Inventory.



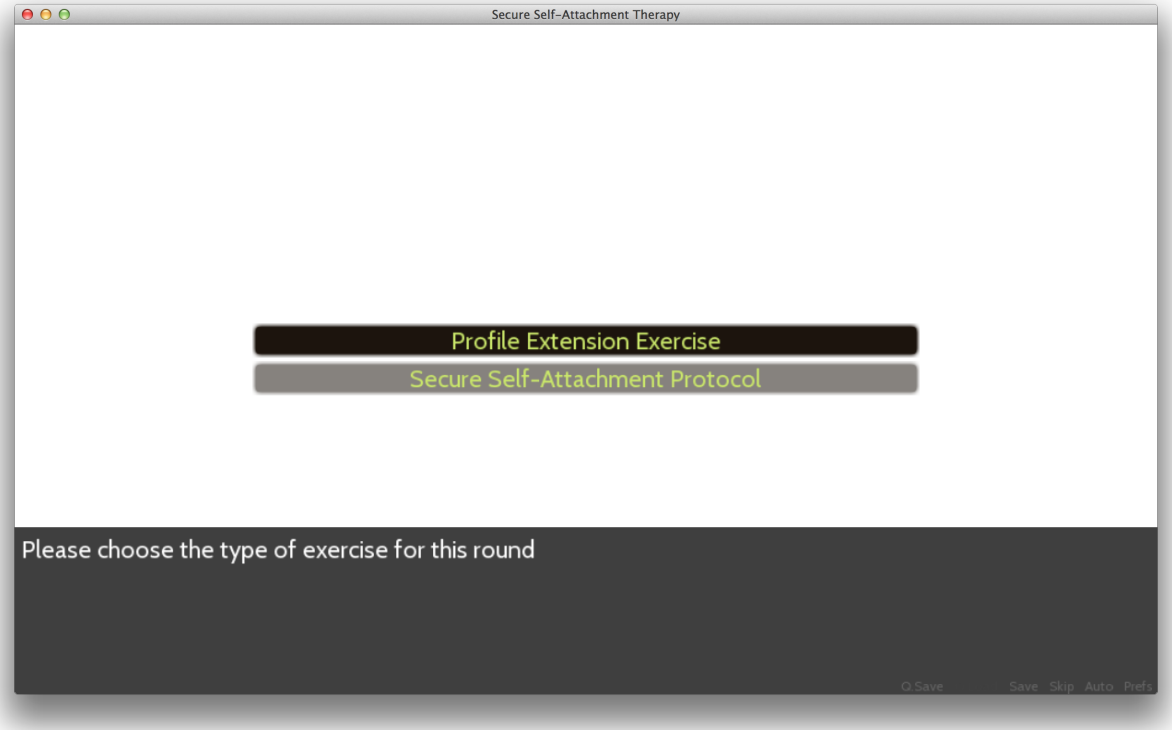
Charles answers the set of 3 questions accordingly.



Charles was then brought to the Game Status screen that showed his overall progress in this set of 5 exercises. He is ready for a round of exercise so he clicks on 'Play'

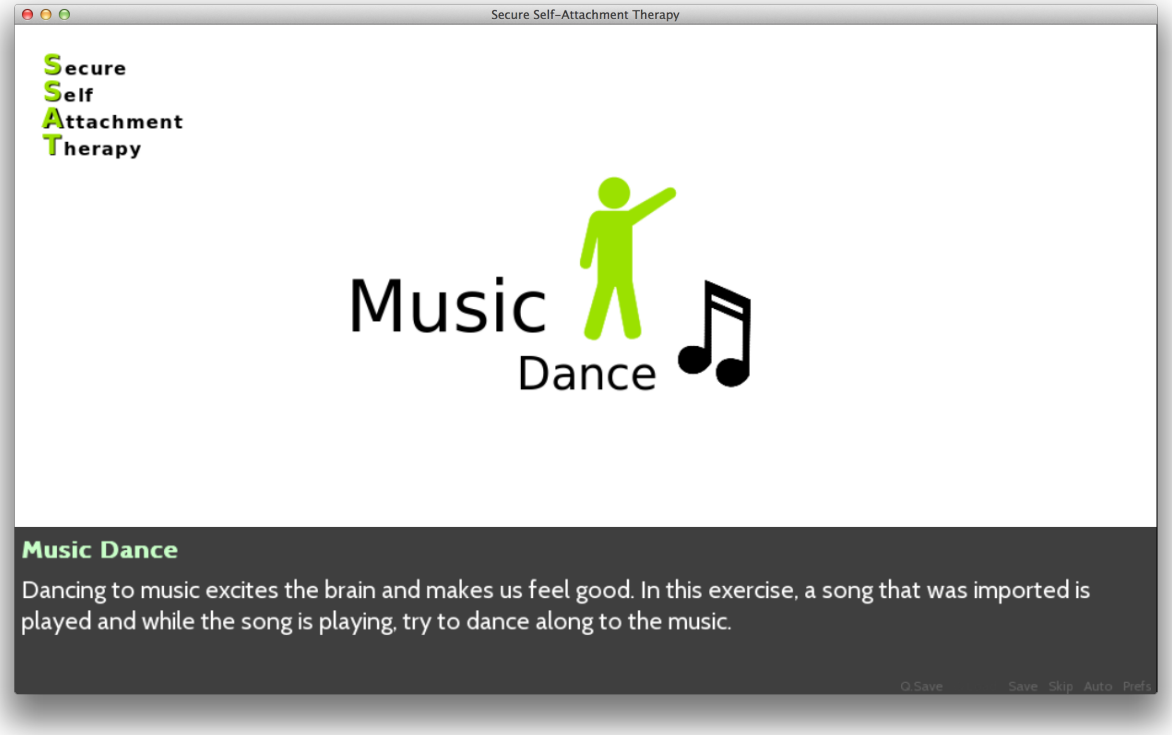


Charles is faced with the decision to either perform a "Profile Extension Exercise" or a "Secure Self-Attachment Protocol". He was feeling extra energetic that day so he decides to click on "Secure Self-Attachment Protocol"

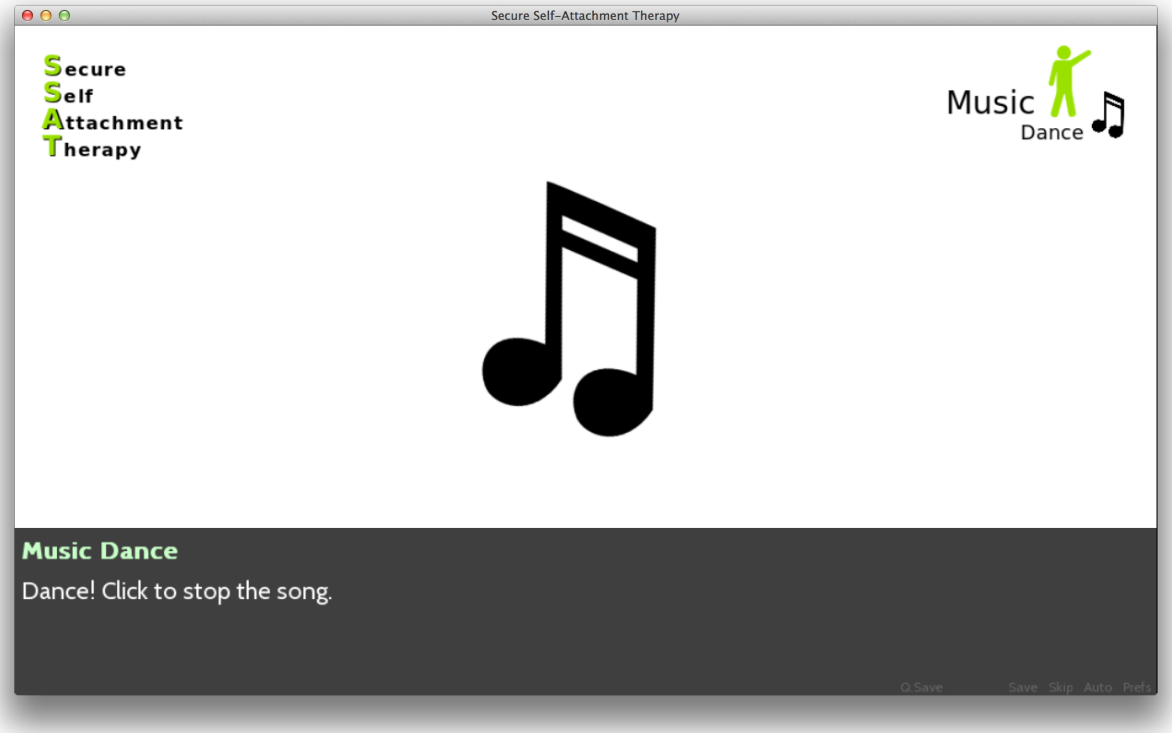


The game presents Charles with an explanation of Secure Self-Attachment Protocol

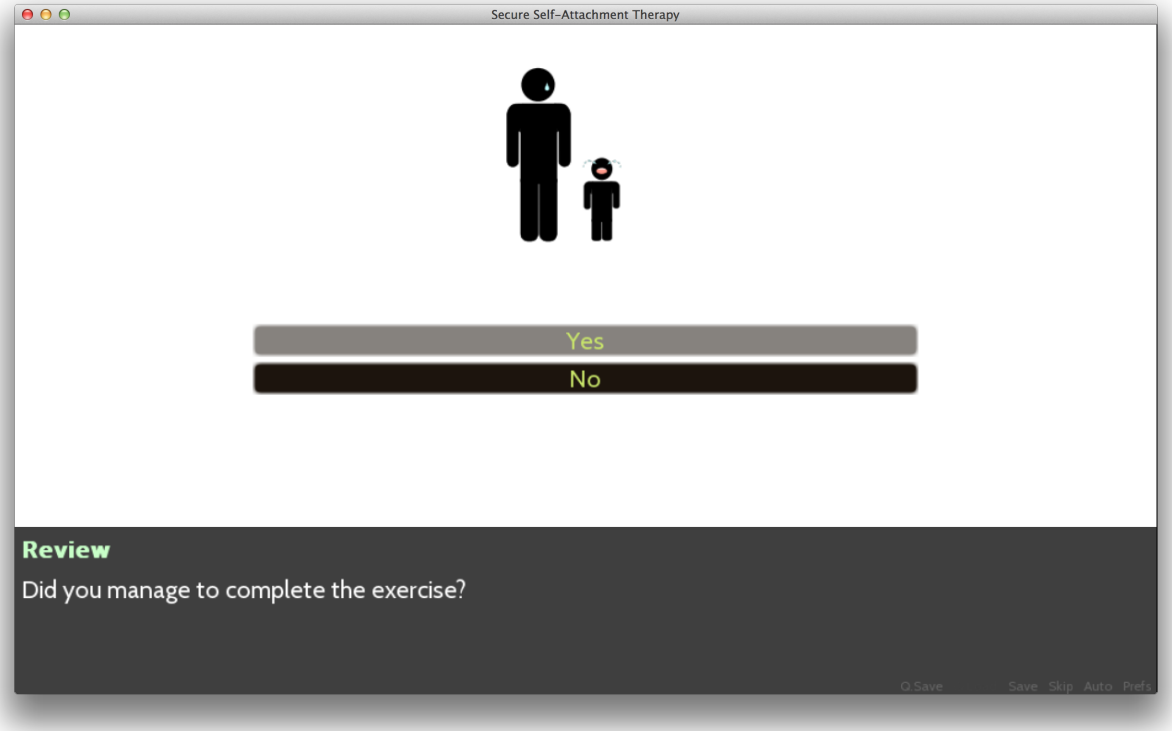
An exercise named “Music Dance” is presented to Charles.



The game plays the song "Somewhere Over the Rainbow" and instructs Charles to dance with the music. Charles had been listening to this song recently so he was in the mood. He dances along to the music until it finished.

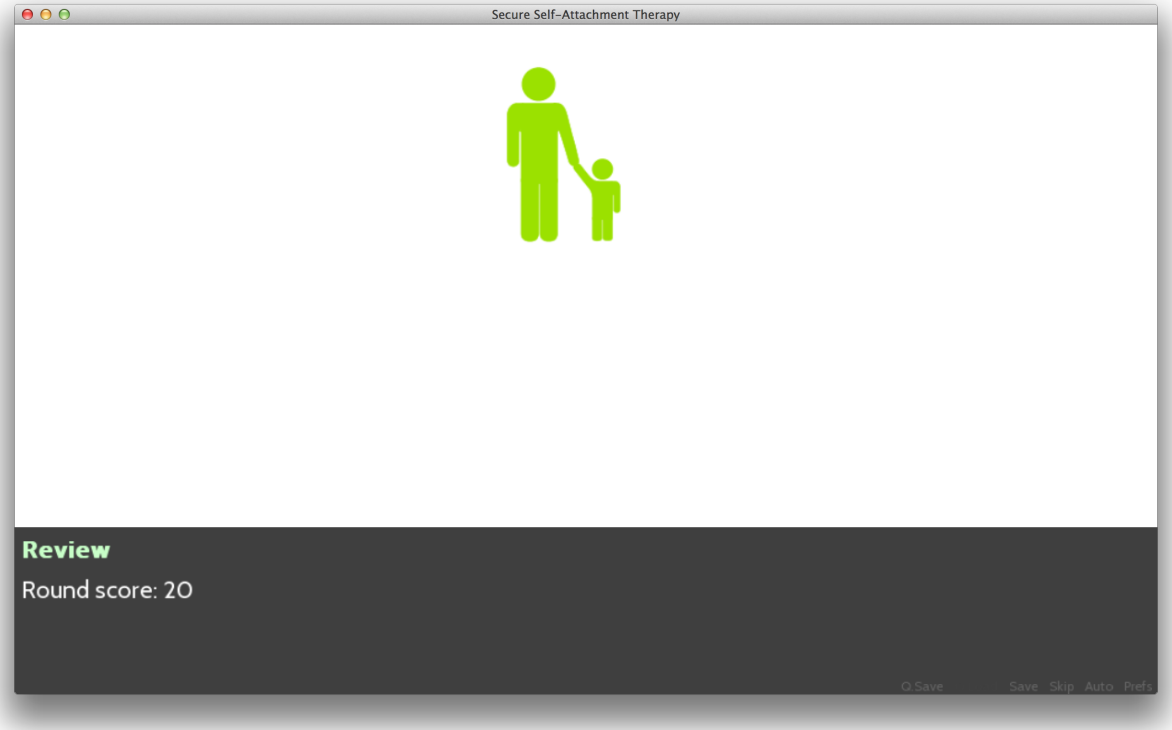


The game asks whether Charles performed the exercise and whether the exercise helped reduce his negative emotions.

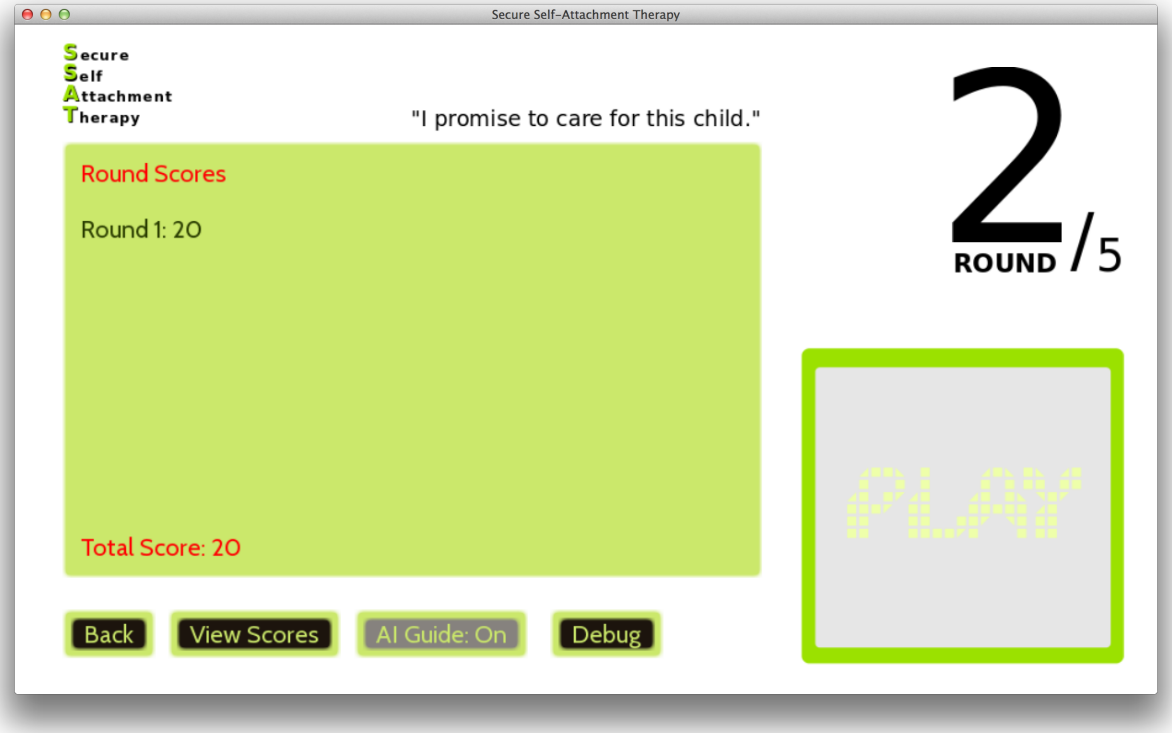


He genuinely felt better from the exercise so Charles selects 'Yes' for both questions.

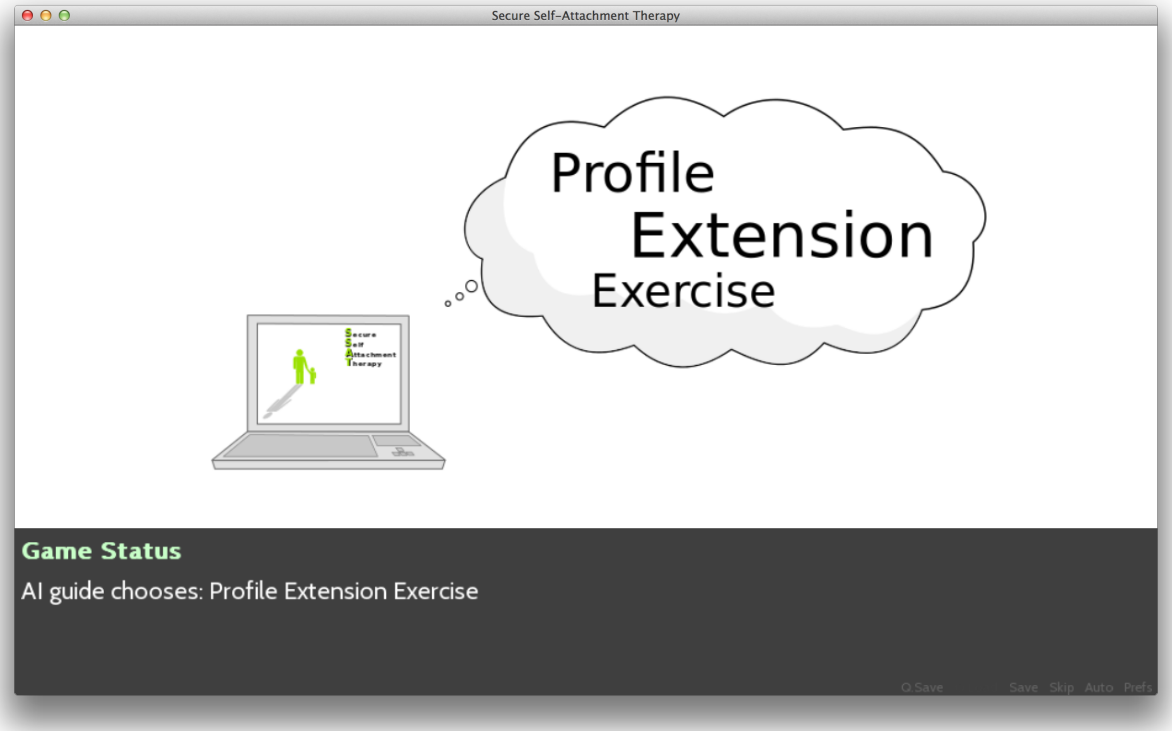
Charles received 20 points from the round of exercise



Charles returns to the Game Status screen where he notices his score displayed on it. He decides to turn on the A.I. Guide so he clicks on the "A.I. Guide" button which enables it. He then proceeds to play another round of exercise.

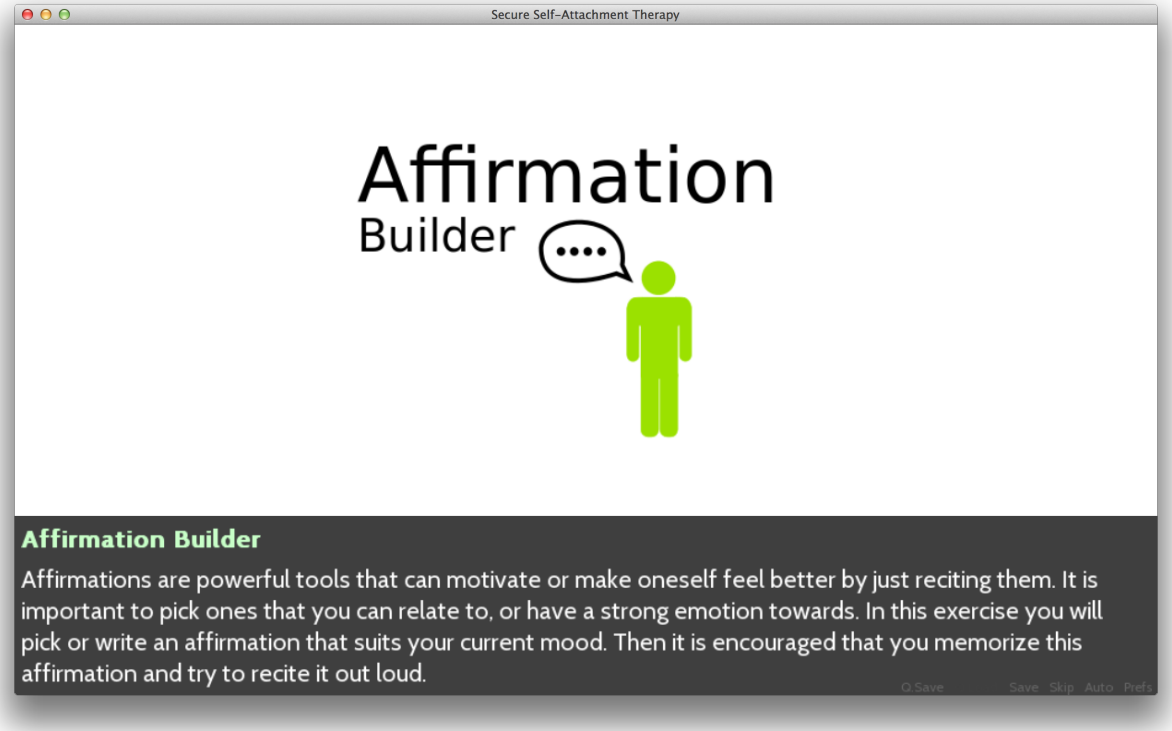


The A.I. chooses to give Charles a Profile Extension Exercise to perform.

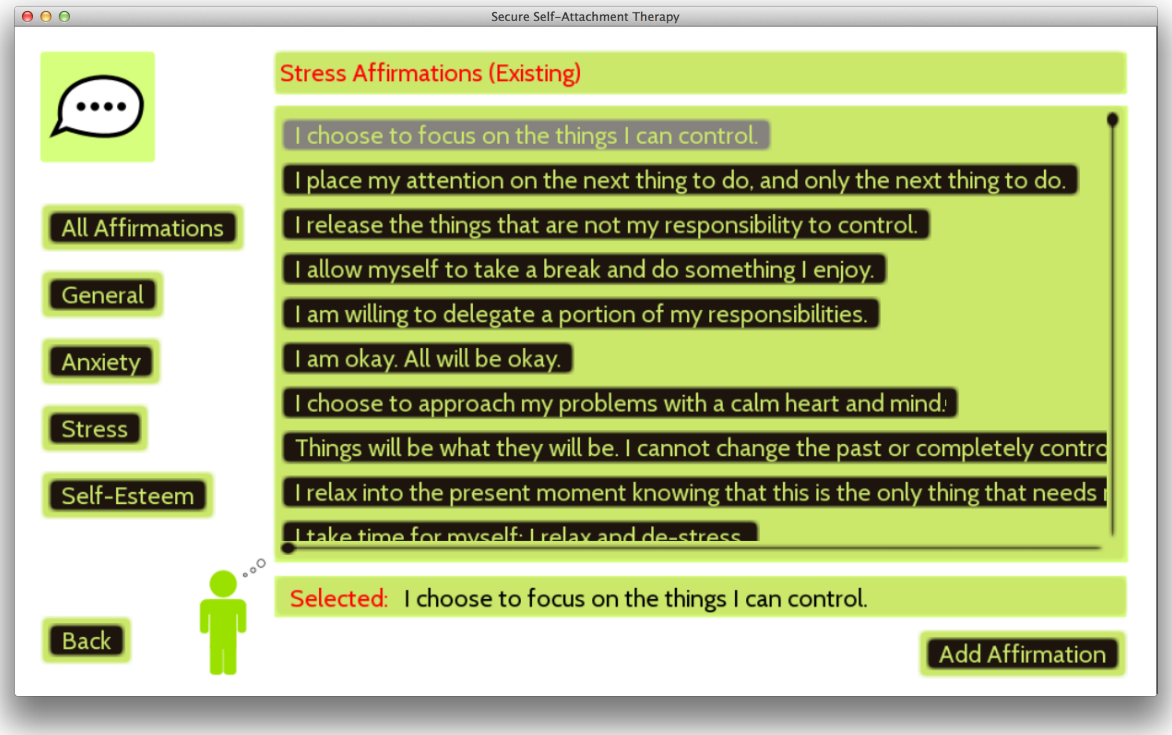


The game presents Charles with an explanation of Profile Extension Exercises .

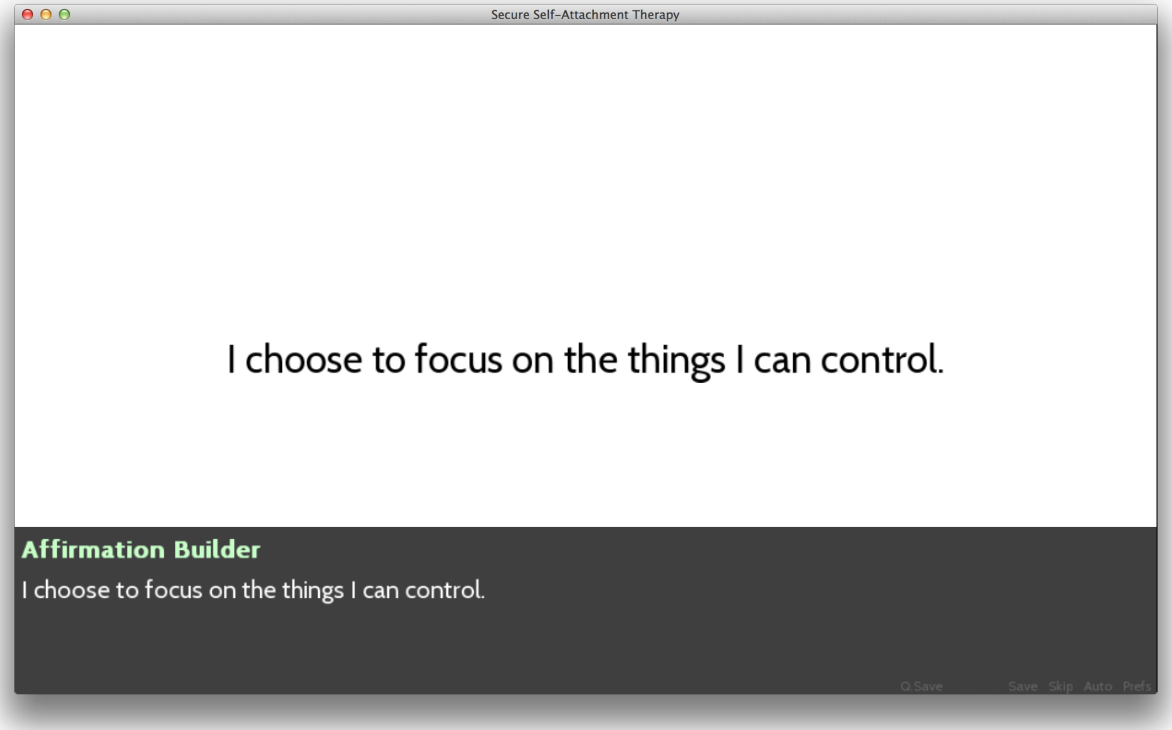
The game selects the “Affirmation Builder” exercise and the instructions are given.



Charles could not think of any affirmations of his own so his decides to pick an existing affirmation. He is presented with a list of affirmations. He was feeling particularly stressed so he clicked on the 'Stress' button to filter through the list of affirmations. He then selects the affirmation "I choose to focus on the things I can control." and clicks on "Add Affirmation".

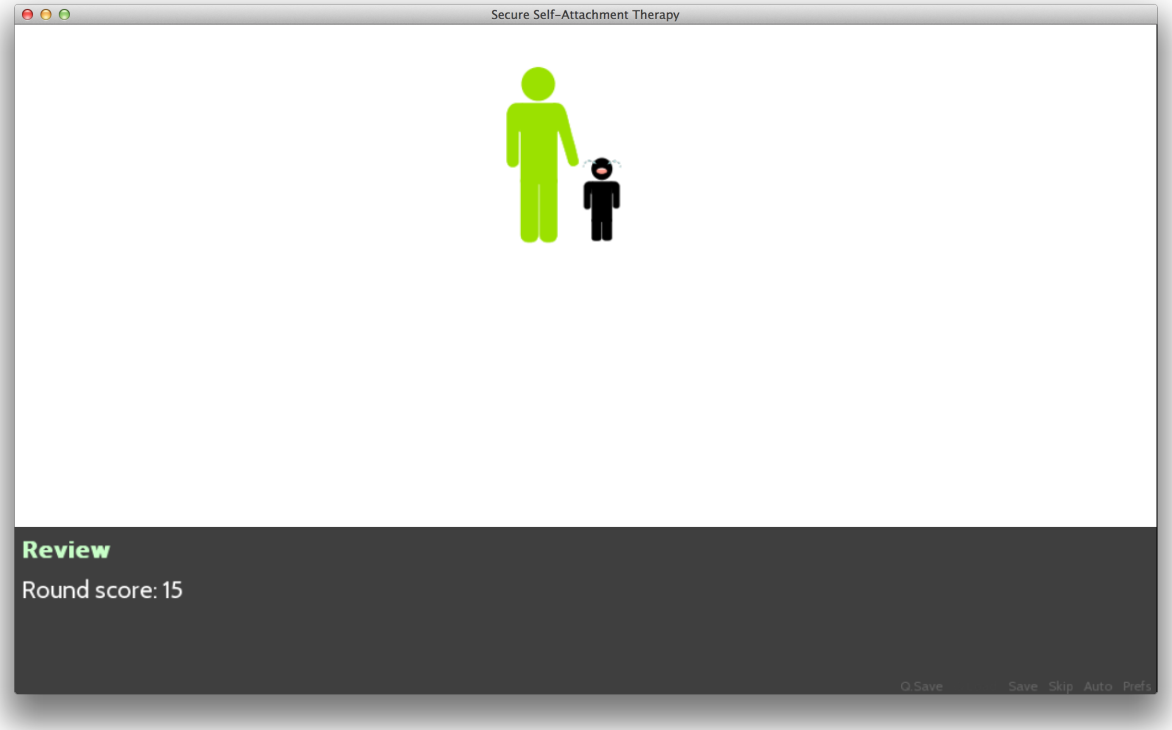


The affirmation is then presented on the screen and the game instructs Charles to remember it.

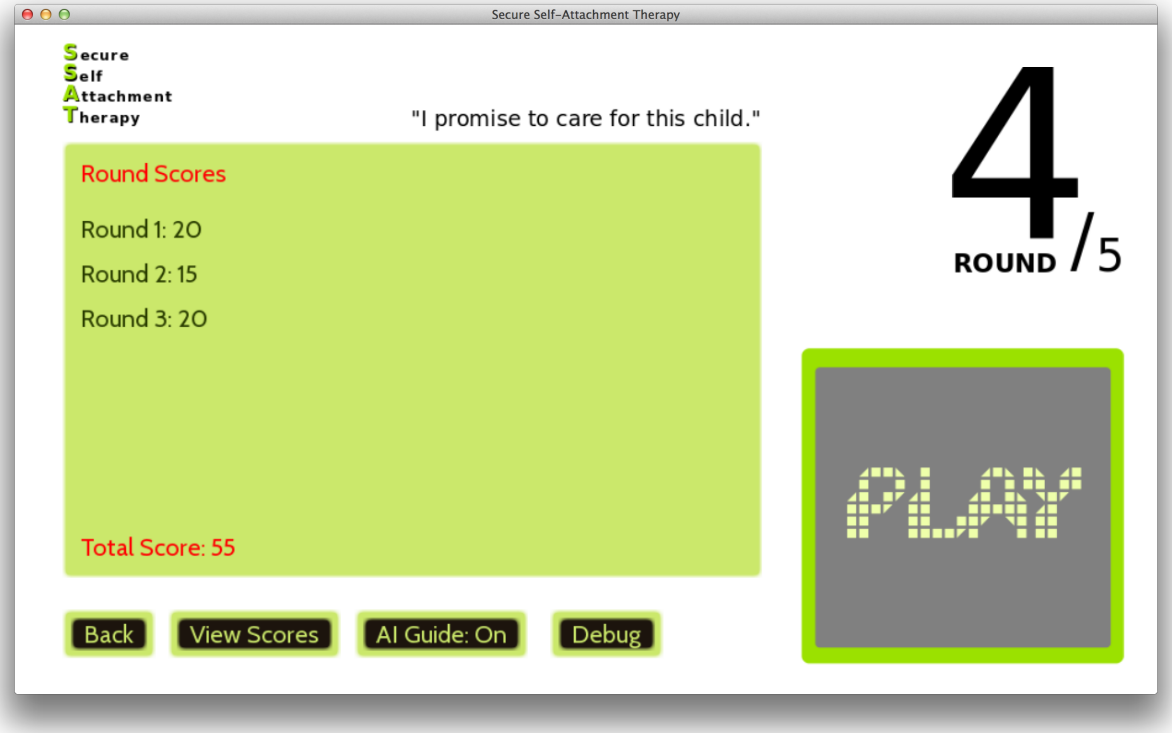


The game asks if Charles performed the exercise which he answers 'Yes'. However when faced with the question whether the exercise reduced his negative emotions, he selected 'No' since it did not make him feel particularly better.

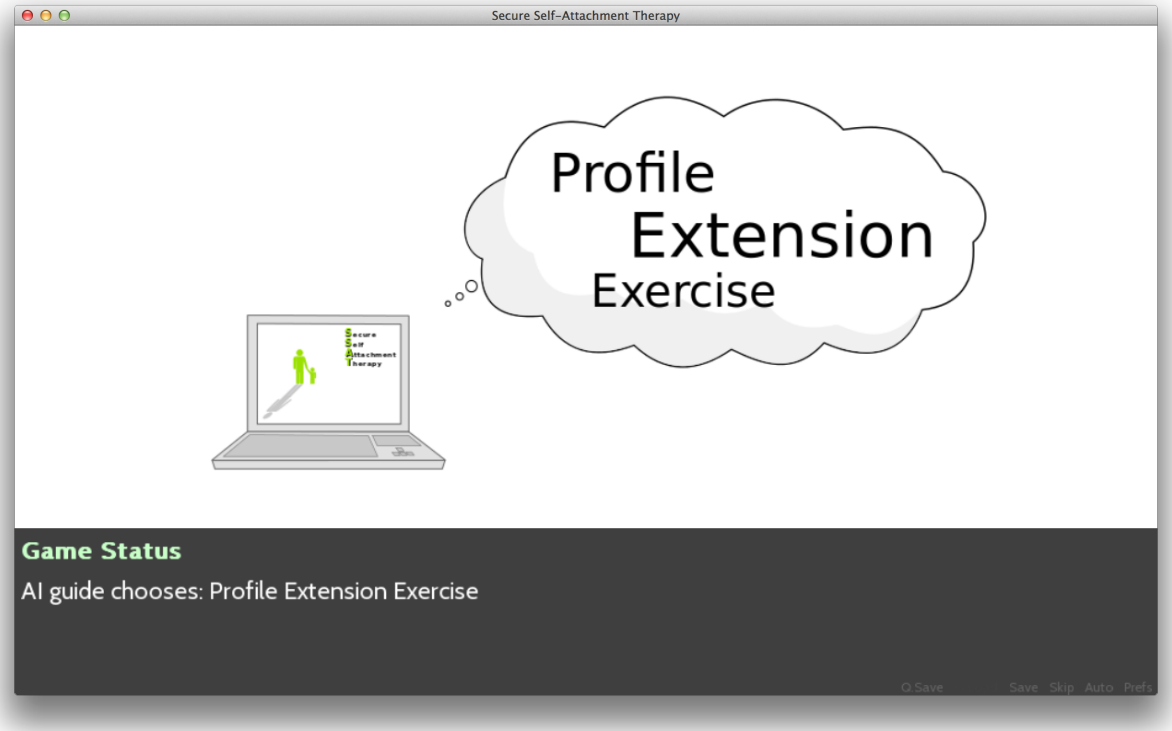
Charles received 15 points for that round of exercise.



Charles was then returned to the Game Status screen and he performs one additional set of exercise. He was presented with an exercise named “Mother’s Touch” and it made him feel a lot better. He received 20 points for that round of exercise. He proceeds to play the fourth round.

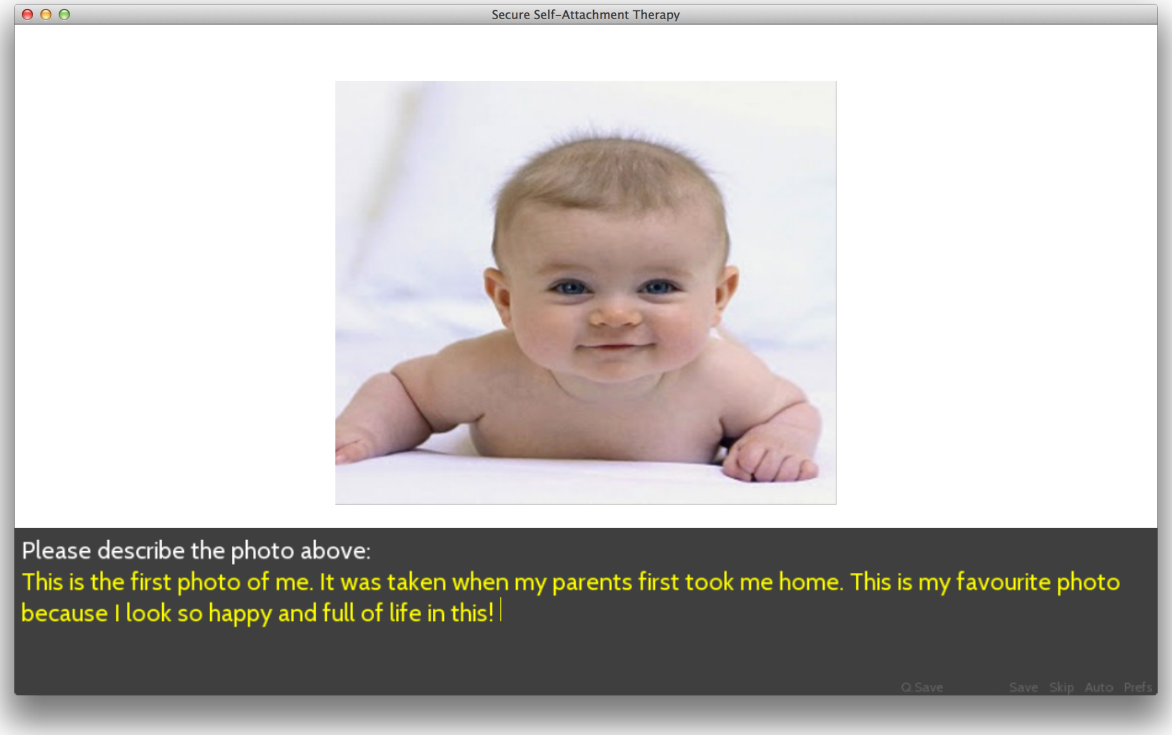


The A.I. Guide selects a Profile Extension Exercise for Charles to perform.

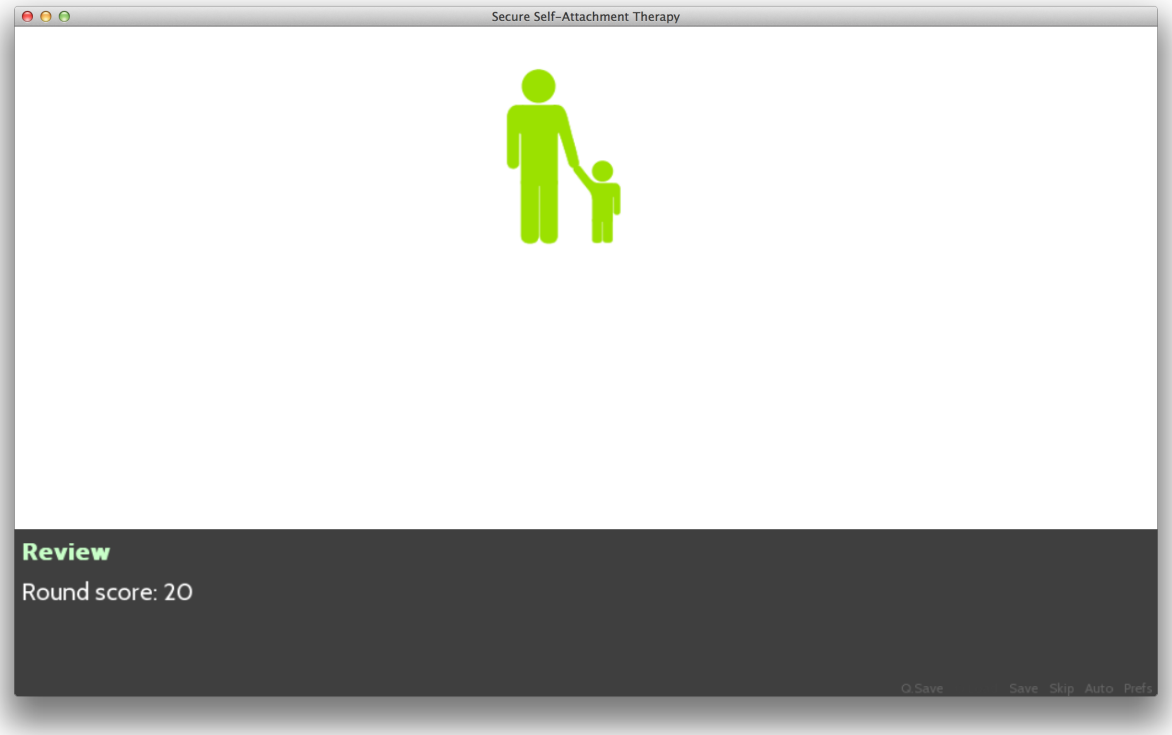


The game selects an exercise named “Photo Description”. The instructions were given to Charles.

Charles is asked to describe his baby photo so he types in the story behind his photo.



Charles was ecstatic to have seen the photo and it made him feel a lot better. So after answering the questions, Charles received 20 points



Charles was presented with the final score screen where it reveals that he scored a total of 75 points out of 100. Charles was determined to get a perfect score next time and decides to return tomorrow for another session.

The game then sends Charles back to the Memory Bank page. He decides he wants to look at the photo album once more so he proceeds to the Photo Album by clicking on the photo visual button.

Charles notices that underneath his baby photo displays the description that he made during the "Photo Description" exercise in the Profile Extension Exercise.

After completing the session, Charles decides to return tomorrow and quits the application.