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Stitched Up in The *Conversengine*: Using Expressive Processing and Multimodal Languages to Create a Character-Driven Interactive Digital Narrative

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Abstract

My practice-based research, which this thesis supports, explores the question: How can a convincing interactive character, with apparent psychological depth, be modelled in a playable digital narrative that adapts to reader choice? To this end I am building my own platform, the *Conversengine*, for authoring and, in future, publishing and playing text-driven interactive narratives that rely on enactment rather than narration. Currently, the platform consists of the *Convowriter*, the authoring tool, which I am using to develop *Stitched Up*, an interactive psychological thriller.

Using the concept of the black box from second-order cybernetics with possible worlds and theory of mind from narratology, I show how combining these theories, mapping one onto another, provides a framework for not only thinking about the character-driven interactive narrative, but also a methodology for authoring one, in both natural language and computer code, and designing its richly responsive visual interface. This incorporates a unique emotional data visualisation system (*emoviz*) to dynamically represent interactive fictional characters. This system is built upon the Pleasure-Arousal-Dominance Emotional State Model (Russell and Mehrabian, 1977) and informed by existing psychological research into colour, shape and motion. I contend that abstract visualisations, coupled with the characters' text-based thoughts and/or speech, can eloquently express convincing mental and emotional behaviour. This provides the feedback in my cybernetic 'steering-a-course' game engine, which, whilst maintaining narrative coherence, allows the reader-player to steer their own course through the narrative.

Creating an interactive narrative of this kind, which simulates psychological rather than physical action, requires a different approach to game writing, development and design. In part two of this thesis, I explore how the distinction between story and narrative discourse has practical implications for the creation of interactive digital narratives. I discuss how using existing game engines and tools can be limiting, and how this led to building my own interactive narrative engine with its own expressive domain-specific language. I show how the combined features of the *Conversengine* offer a new way of representing complex interactive characters with psychological depth.

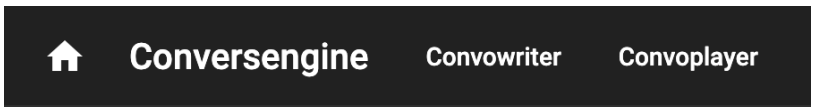
Notes for Examiners

1. Please read this thesis first. In addition to the supporting research, it will explain much of what you'll see in my creative work prototype application.

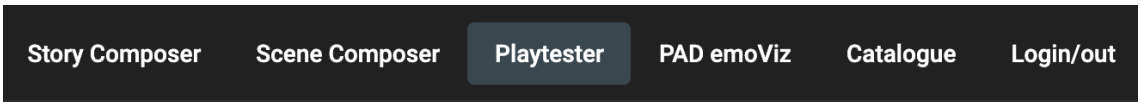
2. Read-play my creative work, *Stitched Up* in The *Conversengine*, a prototype web application that you will find online at: https://convowriter-phd.firebaseapp.com.

3. Login with your email address and password (which you will have received via email) to access the application.

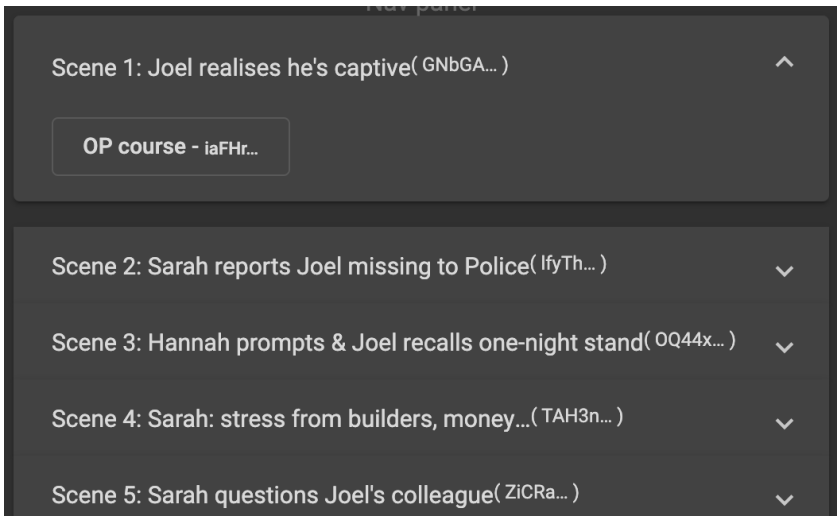
4. Once logged in, click on 'Convowriter' in the menu bar. This will take you to the 'Story Map' which shows the overall structure of my interactive narrative, *Stitched Up*. But first, please read-play through the interactive narrative (see step 5).



5. Click on 'Playtester'. The navigation panel on the left of the Playtester page gives access to the available scenes in *Stitched Up*, which you can play one at a time.

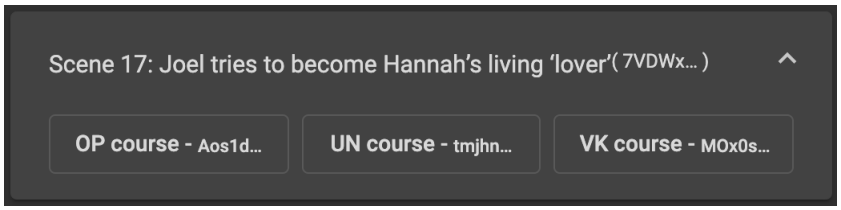


6. Click the scene heading in the navigation panel - a dropdown panel appears showing the available courses to play within that scene.



7. Click the course button to play it. Scenes 1 to 16 only have one course, the default Optimum (OP) course.

8. From scene 17 onwards there are three courses within each scene: Under-par (UN), Optimum (OP) and Overkill (VK).



Feel free to choose whichever course takes your fancy - because this is an authoring tool, I have not implemented the algorithm that determines which course the reader-player would steer to next in the Playtester. However, once you have played a course within a scene, notes will appear in the Dashboard area (on the right) that hint at where your choices may be heading (although they take no account of any accumulative effect).

9. Scene 19, a major turning point in the interactive narrative, is the last of the currently available fully playable scenes. The next link in the navigation panel offers an outline of how the interactive narrative develops towards its multiple endings (this is also reflected in the Story Map).

10. Once you have played through the available scenes in the Playtester, please explore the rest of the authoring tool - in particular, the Story Map on the 'Story Composer' page, the 'Scene Composer', and the 'PAD emoviz'. Rest assured that clicking on any 'Edit', 'Save' or 'Delete' button will have no effect on the saved data in the database.

Contents

Introduction

How can a convincing interactive character, with apparent psychological depth and a rich emotional life, be modelled in a playable digital narrative using expressive programming and multimodal languages, including natural language?

Narratives "by their nature are riddled with gaps" and characters are "some of narrative's most challenging gaps" (Abbott, 2008, p. 132). Filling in these gaps can be an enthralling source of readerly pleasure, especially if they are round characters, complex and multi-layered. On the other hand, flat characters "seem to exist on the surface of the story, along with objects and machines. There are no mysterious gaps to fill since what you see is what you get" (Abbott 2008, p. 133). The majority of simulated characters in videogames and interactive adventures tend to be more flat than round probably because, as Montfort (2007, p. 181) has argued, a flat character can still be compelling and meaningful due to the nature of simulation, especially when combined with narration. Most videogames tend to be structured around physical action whereas my research enquiry stems from the proposition that an interactive narrative can be structured around interior, psychological action and dialogue - that is to say, a digital fiction can be structured around complex interactive character development. My practice-based research explores how I achieve this through the creation of *Stitched Up*, an interactive narrative about human relationships, which employs a range of unique features that constitute (individually and in combination) an original contribution to the field of interactive storytelling.

There is a general expectation amongst creators and players of videogames and interactive graphic adventures that a fictional character within the depicted story world will/should be represented figuratively (with varying degrees of verisimilitude, from 3D realism to 2D cartoon-style). I can understand why: the moment you see a fictional character, a human-like figure, appear and move onscreen, you believe in its existence. But text alone can also conjure up characters, as the novel supremely exemplifies. However, the novel relies, almost invariably[1], on narration to fully form the characters.

[1] Some rare exceptions of novels made up almost entirely of dialogue: *Living* by Henry Green (1929), *A Heritage and It's History* by Ivy Compton-Burnett (1959) or *Deception*

Just as many 3D videogames borrow techniques from cinema, a lot of interactive narratives borrow techniques from the novel. My research presents an original text-based way of modelling rounded, complex characters. Rather than narration-based characters - that is, characters emanating principally from interactive text narration (with or without dialogue) - my project models dramaturgical textual characters - that is, characters as digital actors who can speak and think for themselves, rather than having their thoughts and speech reported via the techniques of narration. The reading-playing experience of my interactive narrative, *Stitched Up*, is about interacting with simulated minds rather than simulated physical representations of characters, objects and environments. I don't use sophisticated Artificial Intelligence (AI) to achieve this, it's more akin to the simulation of minds that arise from the textuality of fiction and drama. Reader-players will find my fictional characters compelling, I hope, because they are rounded and complex, and especially because they undergo character development as a result of reader-player interaction. Specifically, the main characters develop differently depending on the choices the reader-player makes as they progress interactively through the narrative. In my playable psychological thriller, the readerly process of filling in the narrative's mysterious gaps is the core gameplay loop.

In Part 1 of this thesis, I discuss how a convincing interactive character, with apparent psychological depth and a rich emotional life can be modelled by simulating fictional minds, in terms of characters' thoughts, speech and emotional responses. I start out, in section 1.0, comparing enactment versus narration, or the difference between describing or dramatising fictional mental functioning, in interactive narrative and go on to discuss the significance of the absence of a narrator within *Stitched Up*. I then follow, in section 1.1, with a brief review of how some other text-and-choice-based interactive fictions handle narration, enactment and onscreen text and I discuss what makes my approach of diegetic enactment in *Stitched Up* unique. Comparing theories from narratology with writers' theories and advice on creating characters, in section 1.2, I examine what makes a character rounded and complex. Then, in section 1.3, I discuss character complexity in *Stitched Up* and how interaction, via my unique ludonarrative design, affects character development, which is a specific aspect of character complexity. (I also return to discussing character development in *Stitched Up* in relation to my *steering-a-course*

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by Philip Roth (1990)

ludonarrative engine in section 1.6)

Thinking about how to model a complex interactive character in a text-based interactive narrative, without relying on narration, led to the following subsidiary question: What if text, coupled with abstract visualisation, can simply ***be*** the character? What if text can directly represent the character's thought and speech unmediated by narration, diegetic literal devices, or non-diegetic user interface apparatus? In section 1.1, I argue that in the vast majority of interactive narratives not using narration, the text is a second-class citizen, it's extra-diegetic, like subtitles in a film. I point out how, in the rare examples of interactive fiction where the onscreen text in is a first-class citizen but it's not narration, it is rationalised or made literal in the diegesis in the form of text messaging, emails or letters. In contrast, I have developed an original, expressive, multimodal language system to bring text-based interactive characters to life, which combines 'pure' text with abstract visualisation together on the same diegetic (and ontological) plane to embody the fictional character. Together, the text and the visualisation, which is of the character's emotional state (hence its name, *emoviz*), are first-class citizens of the diegesis. They embody and perform the fictional character's speech, thought and emotional expression in an analogous way to how an actor in a stage/screen/radio drama embodies the character they play and performs their lines. I discuss this expressive system, which constitutes an original way of modelling an interactive character in a playable digital narrative using expressive programming and multimodal languages, in sections 1.6 to 1.8.

To create the kinds of convincing complex interactive fictional characters that I've outlined, requires a combination of multimodal expressive techniques. Furthermore, if character development is going to happen in a meaningful way via interactive processes, then an original ludonarrative engine (as opposed to game engine) also becomes necessary, and this is what I have built. These instances of expressive programming combine to form the *Conversengine*. It also includes an authoring tool, the *Convowriter*, for creating such interactive narratives, which I'll discuss momentarily. These works plus the theories that informed their conception and design are part and parcel of my original contribution to knowledge.

With such an interdisciplinary research project, recourse to metaphor becomes essential because "metaphor is not merely a matter of language. It is a matter of conceptual structure" (Lakoff and Johnson, 1980, p. 235). In the design of my creative work - my interactive narrative and authoring platform - I make ample use of metaphor to structure the aesthetic experience and to facilitate the authoring process. Also, throughout my practice-based research, I use metaphor, mapping from one domain to another, to help me explore, understand and conceptualise the relationships between my creative process, the creative artifact and the software I'm engineering to facilitate the creative process and produce the creative work. Metaphor is fundamental to my methodology, it emerges in all kinds of ways: in the language of my creative writing, the domain-specific language of my code and in the conceptual and theoretical design of the work.

Two of my most important guiding metaphors are drawn from second-order cybernetics: the black box and the idea of steering a course (in this instance, through a narrative). Cybernetic concepts are useful to me because, as I'll show, they bridge the gaps between interactive storytelling, computer code, human-computer interaction, narrative theory, the design process and the authoring process. In other words, these concepts inform my approach to modelling interactive characters.

The desire to create 'round' rather than 'flat' fictional characters led me to explore the idea of the interactive fictional character as a black box as a way of simulating psychological depth, which I discuss in section 1.4. Following, in section 1.5, I discuss how I combine the black box concept with Possible Worlds theory and Theory of Mind from narratology. I am drawn to these particular narratological theories because, unlike structuralism, they do not regard fictional characters as purely semiotic constructs but, rather, as make-believe, life-like persons who are "endowed with inner states, knowledge, and belief sets, memories, attitudes and intentions" (Margolin, 1990, p. 455), in short, the features that produce round characters. Unlike most other narratological theories, these particular theories are able to explain how fictional characters can 'arouse emotions in the reader' (Ryan, 2013, para. 21).

Cybernetics, derived from the Greek, 'kybernetes', meaning 'the art of steering', is an interdisciplinary field concerned with complex learning systems based on circular causality (ScienceDirect, 2019). In section 1.6, I explain how cybernetics informs the

design of my expressive ludonarrative engine and how the reader-player steers a course through my interactive digital fiction. I use this seafaring metaphor as a tool for thinking about the craft of interactive storytelling[2].

The feedback cycle is critical in a cybernetic process. In *Stitched Up,* the user (reader-player) receives feedback from the narrative system in the form of text (the characters' dialogue and thoughts) and animated visuals, which are equally important in conveying psychological and emotional action. In section 1.7, I discuss how I represent my fictional characters as abstract visualisations of their internal emotional data and, drawing on the art and science of data visualisation, why I chose this approach as opposed to representing the characters figuratively and animating facial expressions. I explore why and how I used the Pleasure-Arousal-Dominance (PAD) Emotional State Model (Russell & Mehrabian, 1977) from psychology to model emotions as data. In section 1.8, with reference to the psychological research into colour, shape and motion, I detail how I developed my unique *emoviz* system, a proof-of-concept dynamic form of visual narrative ‘language’ to express the characters' emotions.

Overall my thesis shows how the process of developing a creative work gave rise to an authoring platform (eventually with publishing capability too). Building such a platform is highly complex and, therefore, it is currently at an early stage of development: a *minimum viable product* (MVP). Having equipped myself with the conceptual tools to model convincing interactive characters with apparent psychological depth, which is the main focus of part one of this thesis, I was ready to put my theories into practice in a playable digital narrative that adapts to reader choice. Computer science underpins everything digital writers, game developers and creators of electronic literature make, but writers and artists within these fields are not obliged to have a direct relationship with the underlying code. Part two of my thesis explains why I choose to grapple with the code and why I felt it necessary to build my own authoring platform. In section 2.0, I outline my requirements of an authoring tool and present a brief review of existing tools in terms of those requirements. Then I outline the original features of my own authoring tool, the *Convowriter*. In section 2.1, I show how the distinction between

[2] As does Ursula Le Guin with regard to linear narratives in her book "Steering the Craft: A Twenty-First-Century Guide to Sailing the Sea of Story" (2015).

story and narrative discourse has practical implications for the creation of interactive digital narratives and, consequently, the design of an authoring tool. In section 2.2, I show how the creative tools you use can define and limit what you're able to make and express, particularly in terms of the domain-specific languages they make available to you. In sections 2.3 and 2.4, I discuss, therefore, the importance of developing an original domain-specific language for the *Conversengine*, how I arrived at it, and how it meets the expressive needs of the creative project. In particular, in section 2.4, I discuss the unique features of the *Conversengine* from the perspective of finding a shared (or ubiquitous) language that works across the different domains of creative writing and coding interactive narratives. Thus, part two shows how an original concept of modelling complex characters, requires not only the building of an original ludonarrative engine but also an original authoring tool suited to the expression of multimodal languages and natural language. This combination represents a new approach to interactive digital storytelling. Finally, in Reflections, I consider how conceptual black boxes take shape in *Stitched Up* and influence steering a course through the narrative and the creation of round characters. I also reflect upon the experience of using the *Convowriter* authoring tool, and potential future research and developments. In the Conclusion, I summarise my original contribution to knowledge in the field of interactive digital storytelling.

Methodology

Nelson defines practice-based research as ‘theory imbricated within practice’ (2013) and as "an iterative process of ‘doing-reflecting-reading-articulating-doing’" (2013, p. 32). Smith and Dean also describe it as an iterative process, a "cycle of practice-led research and research-led practice", (2009, p. 19). Similarly, Skains outlines a cyclic process in the diagram of her model for creative practice-based research (2016), which also aligns well with Trimingham's notion of a "'hermeneutic-interpretative' spiral model where progress is not linear but circular; a spiral which constantly returns us to our original point of entry but with renewed understanding" (2002, p. 56). These definitions and models also describe my methodological approach and my "multi-mode research inquiry" (Nelson, 2013, p. 32). All involve a cyclical pattern, an iterative process, an oscillation between different modes, which I would also describe as a cybernetic

process.

In *A Model of The Creative Process*, Dubberly et al. (2009, p. 1) describe a process of looping through stages: *observe* > *reflect* > *make* > *observe* > *reflect* > *make* > etc. It can begin with any step, as Smith and Dean also acknowledge (2009, p.19), and each step can loop recursively through the cycle; for example, making also involves observing and reflecting. This, too, is similar to Smith and Dean's idea of sub-cycles within a larger cycle, an 'iterative cyclic web' (2009, p. 19). "Like a self-regulating system, the creative process is a classic feedback loop" (Dubberly et al., 2009, p. 1) and I find the cybernetic model particularly fitting for my practice-based research because it is emphatically interdisciplinary. It can be applied to the cyclic patterns of many fields, including, for example, the scientific method: *observation* > *hypothesis* > *experiment* >; or the design process: *analyze* > *synthesize* > *evaluate* > (Dubberly et al., 2009, p. 1). Indeed, Pangaro and Dubberly claim that cybernetics is a science for design (2013, slides 16, 155).

The classic feedback loop may be sufficient to describe the creative process but creative practice-based research is more complex. Whereas first-order cybernetics is a science of circular, causal systems, ‘a science of goals, interaction, and feedback’ (Dubberly & Pangaro, 2010, p. 2), second-order cybernetics is a science of observing systems, or language-oriented systems. Second-order cybernetics explicitly takes account of the role of observer within the system, therefore it is the recursive application of cybernetics to itself (Umpleby, 2000; Dubberly and Pangaro, 2015a; ‘Second-order cybernetics’, 2020). This seems to me to be an apt description of my methodology, which nests the classic feedback loop of the creative process, and other feedback loops, within the larger feedback loop (or iterative cyclic web) of practice-based research.

When conducting my empirical research (see Skains, 2016), I loop through the creative process, *observe* > *reflect* > *make* >, while creative writing, structuring narrative, animating, designing visuals, performing various multimodal creative experiments, etc. I also loop through the design process, *analyze* > *synthesize* > *evaluate* >, when designing user interaction, ludonarrative algorithms, data structures, applying and/or inventing digital methods and tools, coding, etc., all of which are other forms of empirical research. My contextual research (see Skains, 2016) of relevant creative texts

and critical theory from multi-disciplinary fields involves a cycle of reading, analysing/reflecting, and theorising/writing. From this process of contextual research, I develop theories which I put into practice or test in the creative work itself or the creative process, applying critical theory to practice. The results of these creative experiments feed back into my theoretical thinking/research process. All these sub-cycles, of both empirical and contextual research, nest within a larger iterative cycle which, in my methodology, is comparable to the cybernetic description of the scientific method: *observation* > *hypothesis* > *experiment* >. Therefore, this thesis combined with the creative work, and the iterative cycles of process involved throughout, represent an observing system, cybernetics applied to cybernetics. Since, in addition, I have applied cybernetics in my creative and theoretical work (see sections 1.4 to 1.6), I find this a particularly useful way of thinking about my methodology.

Part 1: Developing *Stitched Up*

1.0 A Meeting of Minds: Enactment vs. Narration

"[T]he constructions of the minds of fictional characters by narrators and readers are central to our understanding of how novels work because, in essence, narrative is the description of fictional mental functioning" (Palmer, 2004, loc. 201). The construction of fictional minds is also central to *Stitched Up*, but the difference is, in my interactive narrative, it is a performance or dramatisation of mental functioning rather than a description.

Stitched Up is a text-based interactive digital narrative. There is no narrator nor any avatar. Instead, the reader-player has direct access to the minds of the two protagonists, Sarah and Joel. Some features of the work have an affinity with aspects of the novel, but other features have more in common with drama. Indeed, I regard *Stitched Up* as an interactive drama that employs textual techniques associated with the novel and short stories. Unlike these forms of narrative fiction and the majority of text-based interactive fictions, *Stitched Up* contains no narration coming from a "primary or global textual narrating voice" (Margolin, 2014, para. 5). From time to time, the characters within the narrative may relate personal stories, but there is no single highest level speech position from which the whole narrative discourse originates. This is an important and distinctive feature of the work, which makes it more like drama (see Hühn and Sommer, 2013). I will show how the particular way this operates in *Stitched Up*, and the combination of features it mobilises, is an original contribution to the field of interactive storytelling.

For clarity and convention's sake, when I'm discussing issues to do with writing the narrative fiction, I will use the term 'character' to refer to a "non-actual individual" (Margolin, 1990, p. 465) within the storyworld, but when I'm discussing issues to do with expressive programming and code, I will use the term 'actor' (e.g. see section 2.4). This is more than a semantic nicety, it is a fundamental distinction because, since the non-actual individuals in *Stitched Up* are not mediated by a narrator, the

characters/actors think and speak for themselves, they act. By which I mean, their utterances are not embedded (quoted or mentioned) within the "macro speech act" of a narrator's voice, "a single, highest-level originator of all originators" (Margolin, 2014, para. 5), they are top-level speech acts in their own right. The characters are digital actors in an interactive drama, performing a combination of words (lexia) and abstract visualisations of emotional responses (see sections 1.7 & 1.8) for the reader-player. This combination is what makes the work innovative.

To dispense with narration in a text-based narrative - especially one which also uses no visual illustrations nor figurative representations of the characters - makes the task of creative writing more challenging. For example, unless it's a natural-seeming part of a protagonist's thought process (to which the reader-player has access), there can be no description of action nor setting. But, for a choice-based interactive narrative like *Stitched Up*, the benefits are worth it. In the absence of a narrator, there can be a more intimate connection between reader-player and character. With no higher narrating authority to depend on or defer to, the reader-player must rely on their own interpretive powers and use their own judgement. Since, in *Stitched Up*, the reader-player has to make choices on behalf of the protagonists, they become embroiled with the character[3], not just empathising with them but feeling responsible too, at least partially, for what happens to them. This combination of enhanced empathic identification and agency may lead to a more profoundly immersive experience.

Furthermore, it has important ramifications with regard to the course the narrative takes for each reading-playing of the work. There is no narratorial voice steering the narrative towards a happy, tragic or ironic ending. The choices the reader-player makes, on behalf of the protagonists, Sarah and Joel, determine the course of the story and its outcome. At every turn, these non-trivial choices are tinged with ethical values or differing temperamental traits and, accumulatively, their results have far-reaching effects on character development. As the narrative progresses three different narrative courses emerge, which I call *Under-par*, *Optimum* and *Overkill*. Over time, the direction of bias of decisions made (which is tracked in the code) will steer a course through the

[3] For example, perhaps, feeling in collusion with the character if they're in a compromising position.

narrative that reflects a tendency[4] towards particular mindsets, world views or outlooks on life. I discuss this original *steering-a-course* ludonarrative structure and the different ethical and temperamental complexions of each course and how this affects character development, a common feature of a rounded character, in section 1.6.

1.1 Text-&-Choice-Based Interactive Fictions

> For many years, it was widely assumed that fiction was narrated, while drama was merely enacted; or, to use Genette‘s terms, that narrative fiction was fundamentally diegetic (though it might contain mimesis in the form of quoted dialogue), while drama was fundamentally mimetic (though it likewise might contain diegesis in internal narrations).
> (Richardson, 2007, p. 151)

Although Richardson goes on to discuss how recent approaches to dramatic theory have modified this basic assumption (2007, p. 151), for my purposes in this discussion, it holds true. When it comes to interactive fictions and narrative-based videogames, one could consider them along a spectrum of how much they have in common with drama and how much in common with narrated fiction. For example, a 3D videogame with (hyper-)realistic human-like characters employs a mode of expression akin to cinematic drama; the animated characters enact the story and speak their own lines. Whereas many text-and-choice-based interactive fictions rely on narration; for example, *80 Days* (Inkle Ltd, 2014), *Blood & Laurels* (Short and Evans, 2014), *Sunless Sea* (Failbetter Games, 2015), *True Legacy* (Blindfire, 2018), all Choice of Games' titles (2020), to mention only a few. Although some of these works contain expressive or illustrative graphics, in all cases, narrated text is their primary means of conveying the interactive story.

On the other hand, in many dialogue-driven choice-based interactive narratives, a visual form of storytelling dominates; for example, *Oxenfree* (Night School Studio, 2016), *Thimbleweed Park* (Gilbert and Winnick, 2017), *Wheels of Aurelia* (Santa Ragione, 2017). In these works graphically rendered characters enact their lines of speech, either

[4] A tendency in the protagonists but also in the reader-player's reading or interpretive approach.

voiced by actors or represented as onscreen text (e.g. speech bubbles, subtitles). Even when using audio speech, these works invariably rely on onscreen text to present interactive options to the player, such as dialogue choices or verbs for interacting with objects or characters - for instance, "Open", "Pick up", "Close", "Look at", "Talk to" in *Thimbleweed Park* (see figure 1). When referring to videogames and interactive narratives, the diegetic level consists of the characters, objects, actions and events within the story world. Any feature that is not part of the story world, and therefore could not be perceived by any character within that story world but is perceivable by the player, is on the extra-diegetic level. Text elements such as the previously mentioned dialogue choices and interaction verbs and other user interface elements (e.g. status icons, menu bars) are extra-diegetic. Speech bubbles, a convention borrowed from comics and graphic novels, might be interpreted as belonging to the diegetic level, but strictly speaking they are not. The speech bubbles are there for the convenience of the reader-player, the graphically rendered characters are not aware of them. *Oxenfree*, which atypically offers dialogue choices in speech bubbles emanating from the character (see figure 2), underscores this because the actual lines of dialogue are voiced by human actors. More commonly though, dialogue alternatives and interactive verb options are presented on an unambiguously extra-diegetic layer of the user interface (see figure 3). Oddly, in *Wheels of Aurelia*, illustrations representing the speaking characters are presented on a clearly extra-diegetic layer, whereas their dialogue is presented in speech bubbles coming from the vehicle within the diegetic realm in which they're travelling (see figure 4). In these kinds of works, no matter how they use onscreen text, it is always subordinate to the graphics.

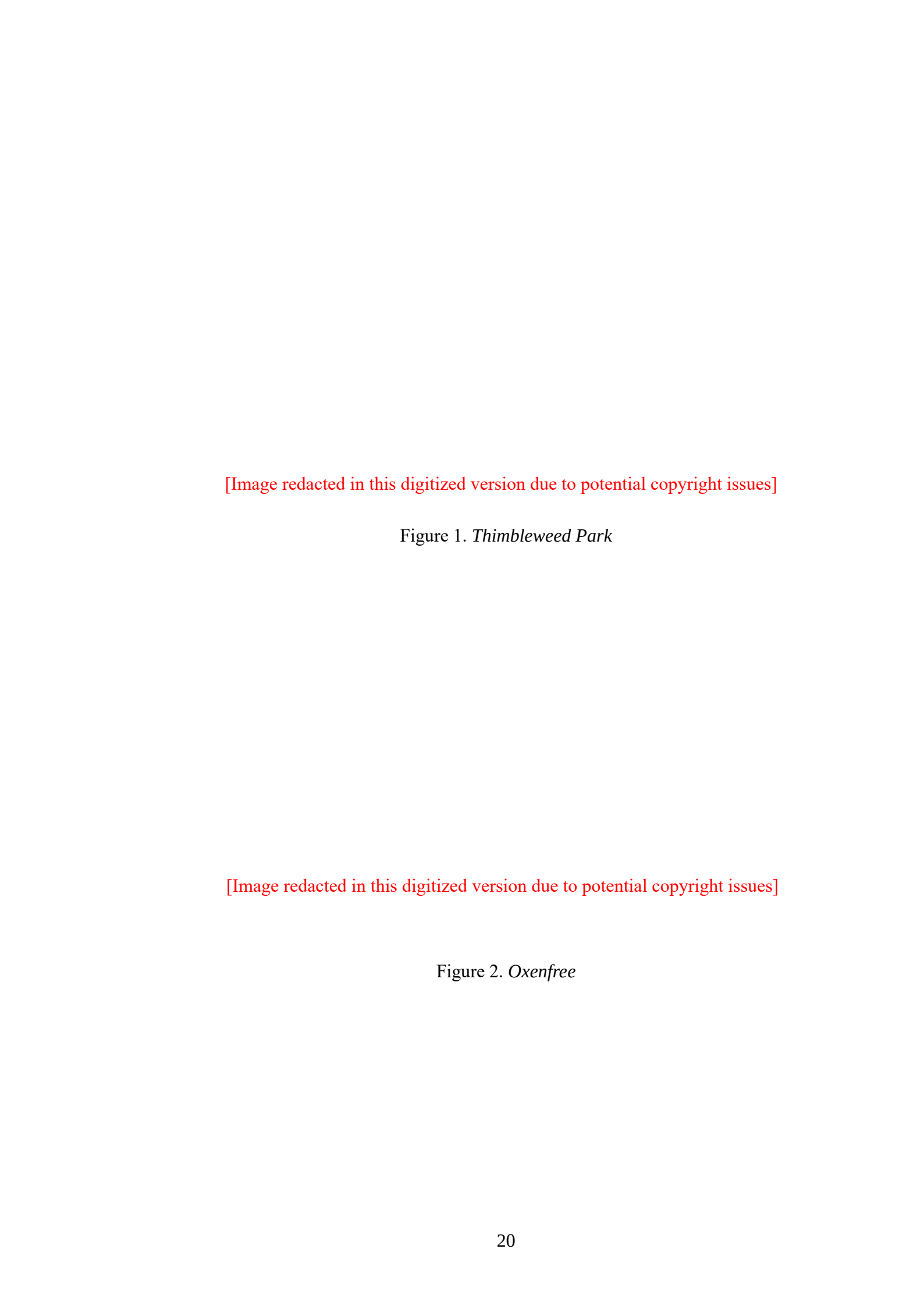

Figure 1. *Thimbleweed Park*

Figure 2. *Oxenfree*

[Image redacted in this digitized version due to potential copyright issues]

Figure 3. *Thimbleweed Park*

[Image redacted in this digitized version due to potential copyright issues]

Figure 4. *Wheels of Aurelia*

Interactive narratives where non-narrated, diegetic text is the dominant means of expression are rare. *First Draft of the Revolution* (Short and Daly; 2012) is an epistolary interactive fiction and even its mode of interaction involves the reader-player 're-writing' the fictional characters' letters (see figure 5). The simulated letters, therefore, are diegetic and have the effect of creating a vivid impression of the characters' mental functioning. However, every now and then, a narrator interjects to explain 'off stage' (or more accurately, 'off letter') action, which I feel dilutes the effect. Both *Bury Me, My*

Love (The Pixel Hunt, Figs; 2017) and *Another Lost Phone: Laura's Story* (Accidental Queens; 2017) are two notable text-and-choice-based interactive narratives in which the onscreen text is entirely diegetic and the characters' words are enacted. Both simulate a fictional mobile phone interface through which the reader-player experiences the story world. *Bury Me, My Love* simulates a fictional SMS text message app (see figure 6), while *Another Lost Phone: Laura's Story* simulates a smartphone operating system (see figure 7). This allows the fictional characters to enact their own words, to speak for themselves entirely via diegetic lexia and so their mental functioning is plausibly enacted but mediated through a literalised textual channel of communication. The presence of text in the story world is thus accounted for, rationalised, via skeuomorphism.

[Image redacted in this digitized version due to potential copyright issues]

Figure 5. *First Draft of the Revolution*

Figure 6. *Bury Me, My Love*

Figure 7. *Another Lost Phone: Laura's Story*

Diegetic Enactment in *Stitched Up*

Lexia in *Stitched Up* receive a unique treatment. My aim is to create simulated minds, rather than simulated bodies and objects. I want to dramatise, rather than describe, mental functioning and to do so without leaning on skeuomorphic textual modes of communication (e.g. letters, emails, text messages). My research inquiry explores what happens in a text-based interactive narrative when the lexia are allowed to simply *be* the fictional character's thoughts or speech, to enact thought and speech directly in the diegetic realm. Also entwined, it explores what happens when, dispensing with visual mimesis, a dynamic abstract visualisation is allowed to enact the character's emotional state on the same diegetic plane as the lexia, therefore metaphorically fleshing out the character. I postulate that not only will this create a heightened sense of the character's presence but, by doing away with extra-diegetic levels and avoiding mediating fictional devices, it will foster a greater intimacy between reader-player and fictional character. These features, which together, I propose, constitute a new form of expressive interactive narrative language[5], are sufficient to create a convincing interactive character, with apparent psychological depth and a rich emotional life - in other words, a complex character.

1.2 Complex Characters with Psychological Depth

In *Aspects of the Novel*, E.M. Forster (1927) divides characters into two types, flat and round. A flat character is a type or caricature, based on a single quality or idea that can be summed up in one sentence. A round character has more than one quality or trait and develops during the course of the narrative, whereas a flat character does not. Forster's broad typology (also commonly known as two-dimensional and three-dimensional characters) is convenient and still widely used. "Critics have long accepted this categorization as plausible, relating it to the way real people are perceived. However, the criteria Forster based it on are vague" (Jannidis, 2013, para. 28).

[5] I use the term 'language' in the same manner as in 'cinematic language'.

Although valuing Forster's "pioneering" analysis, Rimmon-Kenan argues that his “dichotomy is highly reductive” (2003, p.56). She points out weaknesses: some flat characters can seem very alive thus giving the impression of depth (e.g. many of Dickens' characters); some round characters may be complex but do not develop (e.g. Joyce’s Bloom); and some flat characters, simple but developing (e.g. the allegorical Everyman). “Moreover, the lack of development can be presented as arrested development resulting from some psychic trauma, as in the case of Miss Havisham in Dicken’s Great Expectations (1860/61), thus endowing a static character with complexity” (Rimmon-Kenan, 2003, p.56). Instead, she prefers to consider characters in relation to “three continua or axes: complexity, development, penetration into the ‘inner life'” (2003, p.56–57), which can describe a greater range of fictional characters. So, an archetypal flat character would sit at one extreme of all three axes and a complex character, such as Woolf’s Mrs Dalloway, "whose consciousness is presented from within" (2003, p. 57), would sit at the opposite end of all three axes.

Rimmon-Kenan's continua help remedy the vagueness of Forster's criteria but, as Jannidis points out, do not distinguish between "aspects of the character as an entity of the storyworld with those of its presentation" (2013, paragraph 28). Fishelov, on the other hand, does take these aspects into account. Analogous to Forster's flat and round characters, Fishelov differentiates between "a 'type' [and] an 'individual'" (1990, p. 422) and makes a further distinction: "A character may get a flat or round attention on the textual level of the literary work, and he may be perceived as flat or round on the constructed level" (Fishelov, 1990, p. 425). On the textual level, the issues determining flatness or roundness are how the character is presented in terms of their consciousness, number of character traits, being shown from varied points of view and in different situations, and, in some contexts, whether the character has a proper name. The constructed level "is a product of various complex constructing and integrating activities that involve the reader's experience and knowledge of the world" (1990, p. 425). The reader's "attempt to 'match' the various details and patterns provided by the literary work" (1990, p. 425) with their understanding of reality results in an imagined fictional world populated by characters of varying degrees of individualisation. From the combined textual and constructed levels of narrative, four categories of character emerge: *'Pure' type, Individual-like type, Type-like individual, 'Pure' individual* (see Table 1 and Fishelov, 1990, p. 426).

	Constructionally Flat	Constructionally Round
Textually Flat	**'Pure' type**	**Type-like individual**
Textually Round	**Individual-like type**	**'Pure' individual**

Table 1 (see Fishelov, 1990, p. 426)

A *'Pure' type* is the most stylised and a *'Pure' individual* is the most naturalistic or life-like sort of character. An *Individual-like type* is textually rounded but constructed from the text by the reader as a recognisable social type. A *Type-like individual* is a single trait character to whom, nevertheless, the reader attributes psychological depth (as Rimmon-Kenan also observed).

Like Forster, modern-day writers and drama producers have expounded on what makes a fictional character complex and compelling. Theories of character from writers whose main focus is drama (Yorke, 2014; Vogler, 2007; McKee, 1999) interest me, alongside other writers, because *Stitched Up* has much in common with drama, as already discussed.

McKee, whose expertise is in screenwriting, makes a distinction between "*Characterization* and *True Character*" (1999, p. 375), which roughly equate with Fishelov's textual and constructed levels respectively. Characterization is "the sum of all the observable qualities" (McKee, 1999, p. 375); whereas "True Character waits behind this mask. Despite his characterization, at heart who is this person?" (1999, p. 375). The key to 'True Character' is the character's driving desire and motivation, what the character wants and why. For McKee, a rounded character also needs "Dimension" which he defines as a contradiction "either within deep character... or between characterization and deep character" (1999, p. 378).

Vogler, who bases his advice for writers on archetypes from Jungian psychology and Joseph Campbell's mythology studies (see Campbell, 2008), discusses what makes a "well-rounded hero" (Vogler, 2007, p. 37), by which he means protagonist. "A real character, like a real person, is not just a single trait but a unique combination of many qualities and drives, some of them conflicting. And the more conflicting, the better"

(Vogler, 2007, p. 37). A well-rounded protagonist has capacity for "learning or growth" (2007, p. 37) and therefore needs to be flawed: "a Hero who is challenged to overcome inner doubts, errors in thinking, guilt or trauma from the past, or fear of the future" (2007, pp. 39-40), he argues, will be more realistic and engaging.

The notion of a flawed character is also central to Storr's "Sacred Flaw Approach[6]," which is "a character-first process, an attempt to create a story that mimics the various ways a brain creates a life, and which therefore feels true and fresh, and comes pre-loaded with potential drama" (p.7, 2019). Drawing on the findings of neuroscience Storr claims that “Brains take information from the outside world – in whatever form they can – and turn it into models” (Storr, 2019, p. 26) and therefore “we experience the stories we read by building hallucinated models of them in our heads” (Storr, 2019, p.27) as Fishelov describes. Storr submits that life-like complex characters (with psychological depth) have cognitive distortions, biases and erroneous or irrational beliefs that make them flawed. They start out convinced that their cognitive distortions and beliefs are helpful to them but they turn out to be unhelpful and often harmful. For Storr, this provides a rich source for narrative since “All story is change, and the most important change of all that takes place is to your protagonist” (2019, p.223).

Yorke, drawing on long experience as a producer and commissioning editor of British TV drama, shares a similar view:

> “All three-dimensional characters, when we first meet them, are flawed. In psychological terms they are the victims of neurotic trauma: there is a mismatch between their wants and needs; they are dysfunctional, and in order to cope with that dysfunction they have adopted defence mechanisms that help in the short term, but if sustained can cause profound damage.”
> (Yorke, 2014, p.145)

Like McKee, Yorke also maintains that, behind their mask or façade, a fully realized, complex character has hidden depths: "The relationship between what a character wants and their outer façade, between what they need and their inner vulnerabilities – their complete character in other words – is thus inevitably linked to dramatic structure” (Yorke, 2014, p.136).

[6] Storr's approach is applicable to any form of storytelling.

1.3 Character Complexity in *Stitched Up*

When it comes to fictional characters, it seems clear that theorists, writers and drama producers are in general agreement with Margolin that "'Complex' means at least possessing numerous traits stemming from several mental and social faculties. Quite often it also refers to a dynamic structure of tensions and stresses among an individual's diverse mental features, or even to inner conflicts, incompatibilities and contradictions" (1990, p. 464). All these theories have, directly or indirectly, influenced the way I've designed and written the three main characters in *Stitched Up*: the two protagonists, Sarah and Joel; and the primary antagonist, Hannah. I'll provide brief descriptions of these characters to give a suggestion of how their complexity, embedded in textual roundness, is composed of contradictions, façades and flaws. Then I'll go on to discuss penetration of the 'inner life' of the protagonists.

Sarah wants to be a modern career woman with a model home, marriage and family and won't accept anything less than perfection in every sphere of her life. Yet her marriage is floundering and she has 'failed' to become a mother. She wants to be contemporary and progressive whilst also fulfilling a traditional historical ideal of womanhood. Her husband Joel is a software engineer, who, coming from a line of industrial-age mechanical engineers, privately feels a sham. He associates craftsmanship with authenticity and nurses a pipe dream to become a carpenter, a 'real man' like his forbears. He feels undervalued and neglected by his wife. Both Sarah and Joel have invested far too much, financially and emotionally, in trying to restore their Victorian period home, a symbolic repository of their conscious and unconscious aspirations and desires, but for Joel, period authenticity has become an obsession.

Hannah is a traditional upholsterer and furniture restorer, the sole surviving proprietor of a family business going back generations. Alone and friendless, she is a serial adulterer who abhors adulterers. She craves an intimate stable relationship yet only ever seduces married men whom, through her own twisted emotional logic, she is forced to condemn to death, thereby making the men forever 'faithful' to her.

The reader-player experiences the interactive psychological thriller, *Stitched Up,* entirely through the alternating first-person points of view of the two protagonists, Sarah and Joel. There is no narrator. At the start, Joel has disappeared and is being held captive. Sarah, refusing to believe that he has left her, goes in search of him. She meets Hannah, who befriends her and offers to help. Yet, unbeknownst to Sarah, it is Hannah who has ensnared Joel.

The interactive narrative progresses through dialogues and various modes of quizzing - conversations that range from the apparently sympathetic exchange of confidences between new friends, to more devious and malevolent cross-examinations. Ironically, Hannah functions as a kind of sociopathic relationship counsellor since her probings cause both Sarah and Joel, independently, to re-examine their troubled marriage. Since Hannah has never had a wronged wife turn up before, this novel experience and the concomitant double-dealing, which she relishes, prompts her to relate past events and her own personal history. How much is fabrication is up to the reader-player to fathom for themselves.

All three characters, especially the protagonists, undergo significant development throughout the course, or rather, courses of the interactive narrative. The multiple courses of the story in *Stitched Up* mean that the interactive protagonists develop differently, in profoundly meaningful ways, depending on the choices the reader-player makes that determine the course the story takes. In this groundbreaking way, Joel and Sarah's "complete character... is thus inevitably linked to dramatic structure" (Yorke, 2014, p.136). Later, I'll discuss character development more fully in relation to my original *steering-a-course* ludonarrative interactive structure with its *Under-par*, *Optimal* and *Overkill* courses (see section 1.6)

In the case of the two protagonists, Sarah and Joel, their textual roundness is further enriched by ample opportunity to penetrate their 'inner life'. The reader-player has access to their private thoughts as they reflect on past and current events, their feelings, beliefs and intentions. Indeed, the reader-player is often required to make decisions on behalf of Sarah and Joel based on their inner thoughts. As Margolin points out, "an essential aspect of fictional narrative [is] that it can place the reader inside a foreign center of consciousness and enable him to watch in an unmediated fashion the dynamics

of a fictional individual's self and the attempts made by its reflexive consciousness to appropriate past and present aspects and phases of this self" (1990, p.466). To implicate the reader-player directly in this reflexive process deepens the potential immersive experience. In novels and short stories, it's so common to have access to the thoughts of the characters that we take it for granted, but as literary critic Georges Poulet points out, it's actually quite odd. He describes reading fiction as a "strange invasion" of his person as he becomes "a self who is granted the experience of thinking thoughts foreign to him. I am the subject of thoughts other than my own. My consciousness behaves as though it were the consciousness of another" (quoted in Palmer, 2004, loc. 166). In *Stitched Up* the invasion is stranger still because not only is the reader-player the subject of another's thoughts but they have to make their choices for them too. They are occupied interactively by another's mind.

Since there is no narrator, the reader-player can only get to know Hannah from her own, often dubious, spoken words and from whatever Joel and Sarah may think about her. The fact that Hannah is an unreliable character with hidden mental processes, making her a 'black box', is an important feature of the interactive narrative and its playability, as I will discuss.

In real life, neurotypical individuals readily "explain people's behavior in terms of their thoughts, feelings, beliefs, and desires" and cognitive psychologists call this ability "Theory of Mind" or simply "mind-reading" (Zunshine, 2006, loc. 191). The same ability comes into play when reading fiction, "the reader infers the workings of fictional minds and sees these minds in action from observation of characters' behavior and speech" (Palmer, 2004, loc. 187). Hannah is *Stitched Up*'s main non-player character (NPC), the antagonist, whose mind must be constructed in this way by the reader-player since her private thoughts are inaccessible.

However, we frequently misattribute other people's states of minds and, as is often said, we don't always know our own minds, so the potential for misattribution abounds. In Why We Read Fiction, Zunshine (2006) makes the case that reading fiction pleasurably stimulates our mind-reading ability, which we find enjoyable both when we get it right and when we get it wrong (e.g. suspecting innocent characters in a whodunit). As an interactive fiction, Stitched Up exploits this. It puts Theory of Mind into play, with

respect to both protagonists and antagonist, in multiple and sometimes innovatory ways, making it an essential feature of its ludonarrative play.

The originating concept of *Stitched Up*, and another way of thinking about it, is as an interactive narrative based upon the idea of a fictional character as a 'black box'. An observer (or investigator) can only infer what's inside a black box from its inputs and outputs. "Once an entity in the storyworld is identified as a character, ... there is an invisible 'inside' which is the source of all intentions, wishes, etc., and a visible 'outside' which can be perceived" (Jannidis, 2013, para. 15). So a reader-player can only infer what a black box character is thinking and feeling from their outputs, from their behaviour or what they say, by applying their Theory of Mind. Hannah is the quintessential black box character in *Stitched Up,* but, since people have complex biases and blind spots, Sarah and Joel are black boxes too in many respects.

Behaviourist psychologists, in the first half of the twentieth century, treated the human mind as a black box because its internal workings were inaccessible to scientific study at that period. They studied behaviour instead and developed the stimulus-response model (Friedenberg & Silverman 2011, pp. 75-76). This gave narratology the concept of behaviourist narrative where the author only conveys the characters' external behaviour, not their inner thoughts and feelings - for example, fiction by Ernest Hemingway, Raymond Chandler or Dashiell Hammett (Palmer, 2004, loc. 2089, 3061).

Additionally, the concepts of the black box, of inputs and outputs, stimuli and responses are integral to computer software and human-computer interaction and, therefore, essential to videogames and interactive narratives. Since "our conceptual system is largely metaphorical" (Lakoff and Johnson, 1980, p. 3), these correlations are particularly fruitful for my project as they provide a rich source of functional and aesthetic metaphors with which to work, in both theory and practice. This is what my thesis explores.

In the next section, I will draw together the concept of the black box from cybernetics with Possible Worlds theory and Theory of Mind from narratology to show how combining these abstractions, mapping one onto the other, can create a framework for not only thinking about character-driven interactive digital narratives, but can also

provide a methodology for authoring them.

First, I will look at the black box concept in more detail, then show how it relates to fictional characters, Theory of Mind and possible worlds.

1.4 The Black Box

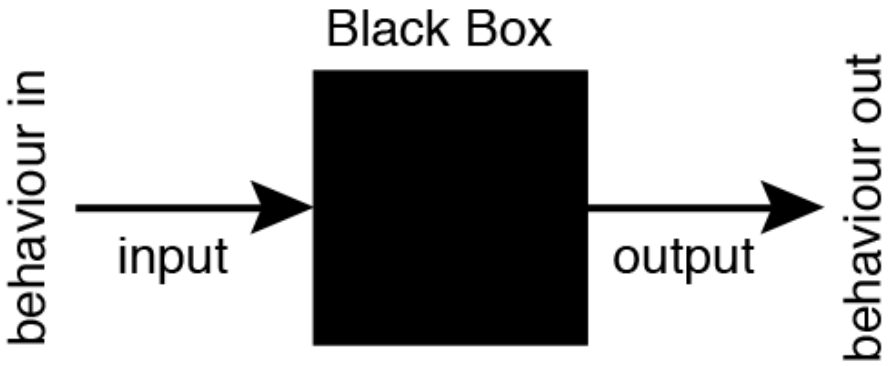

Figure 8. Black Box input & output

The black box first appeared in 1867 as a thought experiment by James Clerk Maxwell in the field of thermodynamics (Glanville, 2009; Edwards, 2010). The concept enabled him to build functioning descriptions that would account for the observed behaviour of some phenomenon when its workings were not clearly visible.

> The blackness of Maxwell's box is taken (as an allegory) to indicate that we can see nothing: it is dark. By extension, the blackness is taken to indicate that we do not know what is inside the box and cannot see what (if anything) is within. The boxiness of his box is taken to indicate that we assume there is some mechanism inside the box, even if we cannot see it.
> (Glanville, 2009, p. 153)

This approach proved to be useful for engineers when faced with the unknown - the most striking example being an object that might be a bomb - but it is also useful in software engineering when a programmer wants to encapsulate their code (e.g. to

protect it from being interfered with by external objects). However, psychologist and cyberneticist, W. Ross Ashby, found the range of applications for black box theory to be much wider than engineering, even extending to daily life (Ashby, 1956). Ranulph Glanville, a leading figure in Cybernetics, developed the concept further by examining the role of the observer of (and in) the black box. He describes engineering applications as "weak versions" of Maxwell's thought-experiment and stresses the importance of remembering that the "Black Box is not a physical object, but a concept (a phantasm)" (2009, p. 154). Indeed, while I make use of concrete applications when I write code for my interactive narrative, I find the phantasmal nature of the black box to be its most intriguing aspect. As a creative practitioner, I am always interested in how form and content impact on each other and I will discuss this more later, but for now, I will focus on how one can make use of a black box phantasm.

> Imagine you see something going on, you don't know what, but there seems to be some action which you might be able to call behaviour. It's unclear, it's a mess, but you're curious. To investigate this, you impose a Black Box on the mess (as an ordering concept).
> (Glanville, 2009, p. 154)

Then you interact with the black box, manipulating the inputs and observing the outputs, looking for a pattern that links behaviour in with behaviour out, which will provide an explanation or, to use Glanville's term, a "functional description" of what is going on inside the black box. In this way, the observer or investigator is an active participant in forming and operating the black box. So it is a system that includes the observer - in other words, it is an observing system (see figure 9).

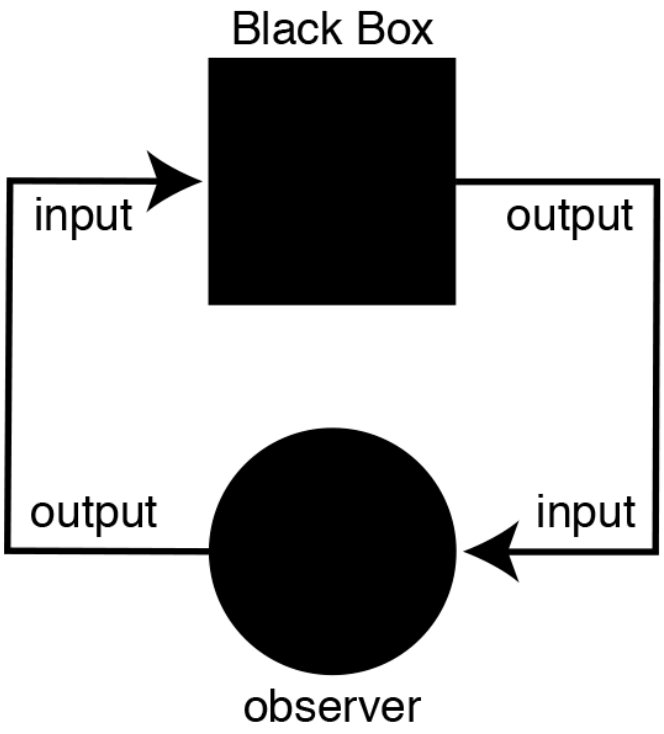

Figure 9. Black Box and the observer

This act of imposing a black box on some thing or some situation and detecting a repeatable pattern of inputs and outputs makes it appear as if it is a matter of cause and effect, but that is an illusion. The blackness of the box means you cannot know what is actually happening inside it, that is hidden, so you cannot identify a cause, you can only arrive at an explanation - a "functional description". If you observe that the pattern of input and output persists, you have confirmation that the explanation you have deduced is still valid. That's all.

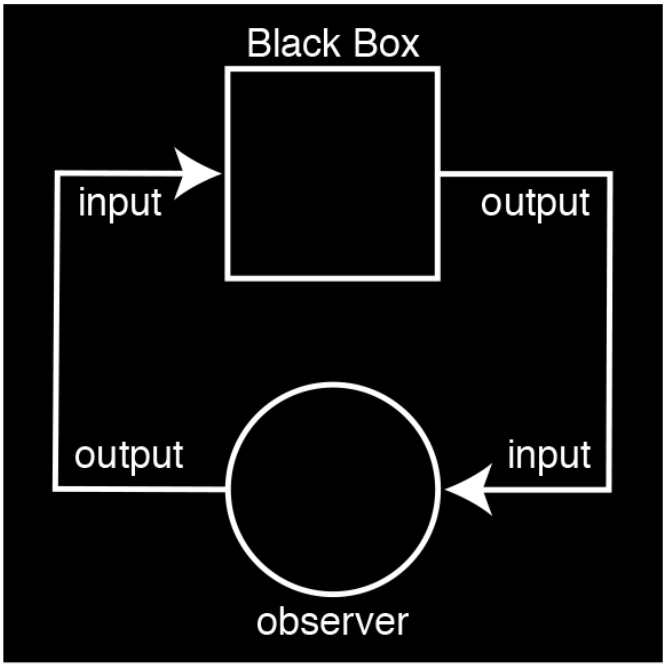

Figure 10. the (new) whole

So the black box and the observer are linked in a circularity, or a feedback loop, and together they make what Glanville calls "a (new) whole" (see figure 10). To another outside observer, this (new) whole is also a Black Box and together that "(new) observer" and the "(new) Black Box" forms "a (new (new)) whole" (see figure 11) and so on, recursively (Glanville, 2009, p. 164). The observers in this nested recursive pattern do not have to be different individuals, they can be the same person observing their own behaviour as an observer within the system. Indeed, Glanville proposed that this self-awareness, this ability to transcend the boundaries of the black box "may be at the heart of human consciousness" (Glanville, 2009, p. 165).

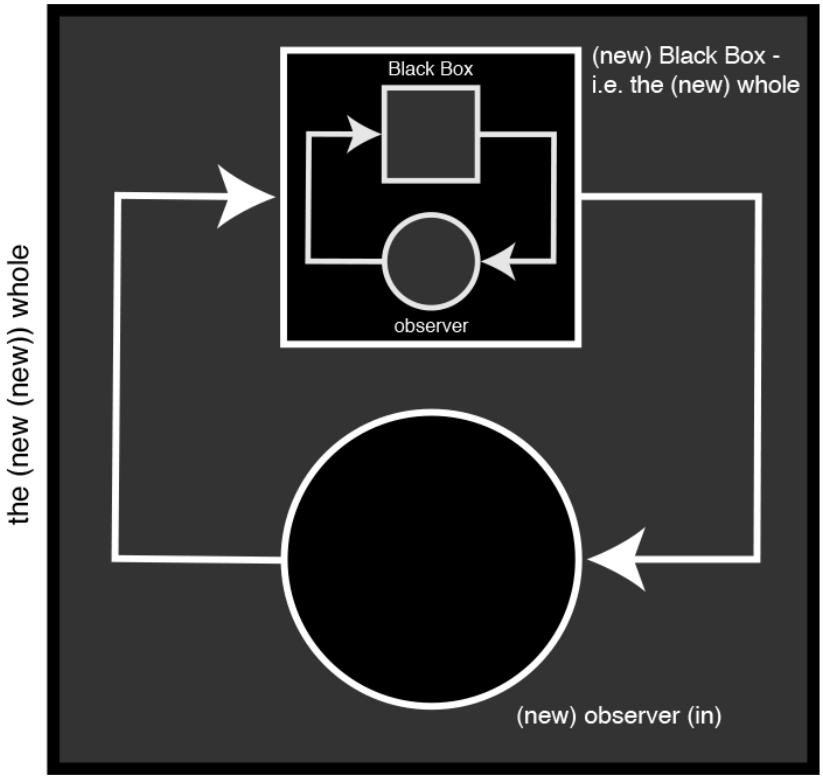

Figure 11. the (new (new)) whole

It is striking to me how well Glanville's description applies to the process of human interaction, to observing and interpreting human behaviour, and also to the reading of fiction. If we regard the fictional character as a black box, we can view the reader as an observer or investigator. As Zunshine points out, readers need very little prompting "to begin to attribute a mind of her own to a fictional character... since any indication that we are dealing with an entity capable of self-initiated action..." - any behaviour output from the black box character - "leads us to assume that this entity possesses thoughts, feelings, and desires, at least some of which we could intuit, interpret, and, frequently, misinterpret" (2006, loc. 429). And fiction writers exploit this "as they experiment with the amount and kind of interpretation of the characters' mental states that they themselves supply and that they expect us to supply" (Zunshine, 2006, loc. 433).

Apart from the absence of a narrator, *Stitched Up* employs techniques in common with fiction to supply mental states but it also conveys them via a unique dynamic emotional

data visualisation system - my emoviz system - which I will discuss in detail in sections 1.4 and 1.5.

1.5 Possible Worlds

According to Palmer, "Discussions on how fictional minds are constructed have to be put in the context of possible-worlds theory" (2004, loc. 505). And this is where I now turn, also with the purpose of seeing how Possible Worlds relates to the black box concept as applied to my interactive digital narrative.

IRIS (a European Network of Excellence in Interactive Storytelling research) has identified Possible Worlds as a "natural option" for Interactive Storytelling (2012, para. 7). However they tend to look at the theory from an Artificial Intelligence perspective and, showing their bias towards machine implementation, they point out that "current AI algorithms make limited use of the possible worlds they generate" (IRIS, 2012, para. 7). By taking a cybernetic rather than an AI approach (more on this section 1.6), I am putting Possible Worlds theory to work in a different way, which I believe is more productive for my brand of interactive storytelling, by using it in conjunction with the black box concept.

Although some narratologists (Ryan, 2006, 2013; Bell, 2010) have identified Possible Worlds theory as a particularly useful approach for the analysis of interactive texts and games, the concept was first applied to more traditional linear narrative forms from the 1970s onwards (Ryan, 2013). For instance, Umberto Eco declared that a narrative text "is a machine for producing possible worlds (of the *fabula*, of the characters within the *fabula*, and of the reader outside the *fabula*)" (1979, p. 246).

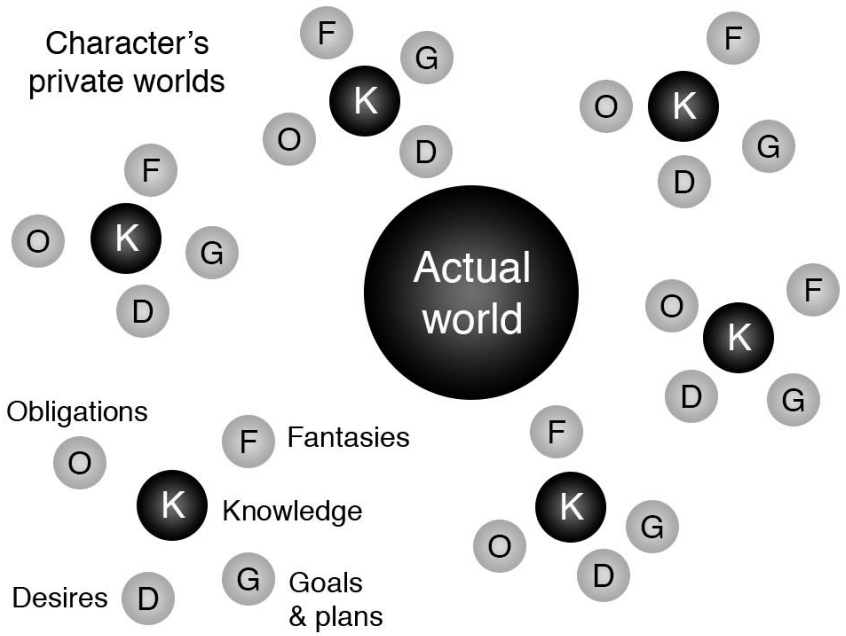

Figure 12. Ryan's diagram of the semantic universe of possible worlds (2006, p. 648)

Inspired by Eco, Marie-Laure Ryan developed the theory further. Ryan's diagram (see figure 12) gives a good overview representation of the "semantic universe" (2006, p. 648) of possible worlds in non-interactive linear forms such as the novel or film. The "Actual World" of the system is "constituted by the facts legitimately asserted by the narrator" which readers accept unconditionally (unless it turns out to be an unreliable narrator). "[T]he fictional text creates its own world and its own facts, even though it pretends—and invites the reader to pretend—that it is describing an extratextual reality" (Ryan, 2006, pp. 648-649). Ryan also calls this the "textual actual world" (2013, para. 16). "Surrounding this ontological center are the little solar systems formed by the private universes of the characters" (Ryan, 2006, p. 649). These private universes represent the mental life of the characters; including their desires, obligations, fantasies, goals and plans; and each character's subsystem is centred around their own knowledge world:

> …which holds the character's representation of the entire system: this is to say, of both the actual world and the private worlds of the other characters (which themselves contain images of the private worlds of the character under consideration in a mirroring process that would lead to endless recursion if it were not for the limitations of the human mind).
> (Ryan, 2006, p. 649)

Notice the similarities between Ryan's account of narrative possible worlds and the observing systems of cybernetics - the black box and observer together, forming a new whole, which in turn is a black box to another observer and so on, black boxes recursively nested inside each other.

Recursion is also reflected in Theory of Mind. Although it "is formally defined as a second-order intentionality--for example, 'I believe that you desire X,'" (Zunshine, 2006, loc. 546), Theory of Mind can also explain our ability to navigate multiple levels in a narrative; up to a limit. Cognitive scientists have shown "that people have marked difficulties processing stories that involve mind-reading above the fourth level" of intentionality, "as in 'I believe that you think that she believes that he thinks that X,'" (Zunshine, 2006, loc. 546-562).

In all this, there is more than surface resemblance, there's a significant pattern. So, mapping one concept onto the other, Ryan's "private worlds" of fictional characters are also black boxes and this directly influences how I write and construct my fictional characters in *Stitched Up*. Furthermore, nested within a psychologically deep character, there may be internal black boxes that are opaque to the character too - subconscious desires for instance.

Possible Worlds Mapped onto the Black Box

A machine for producing black boxes

Here I adapt and extend Eco's idea of a narrative being "a machine for producing possible worlds" (1979, p. 246). I propose that, in addition, an interactive digital narrative is also a machine for producing black boxes: of the story; of the characters within the story; of the reader-player *playing in character*; and of the reader-player outside the story.

Whereas Eco identified three categories, I define four categories of black box observing systems, each one also being a possible worlds category (see table 2). I'll discuss each in turn.

Black boxes & possible worlds from interactive digital narrative machine	**Possible worlds from Eco's narrative machine**
the story	the *fabula*
the characters within the story	the characters within the *fabula*
the reader-player *in character*	
the reader-player outside the story	the reader outside the *fabula*

Table 2.

The black box of the story corresponds, in Eco's schema, to the possible worlds of the *fabula*, which are imagined and posited by the author. Referring to non-interactive narratives, Ryan describes these possible worlds as "a succession of distinct states mediated by events. These states correspond to objectively occurring physical states, and they can be regarded as the actual world of the narrative system" (Ryan 2013, para. 14). In a playable narrative these distinct states are mediated not only by events but also by the reader's choices, so there are numerous potential actual worlds in an interactive narrative system. In this case, the black box of the story is an observing narrative system where the reader-player's input affects the narrative output and the reader is a participating observer in, *and of,* the system.

The black boxes of the characters within the story correspond to the possible sub-worlds of the characters within the *fabula* in Eco's schema - i.e. what the characters imagine, believe or desire, their "mental activity through which they react to the changes of state that occur in the physical world or to their idea of what happens in the mind of other characters" (Ryan, 2013, para. 14). For the reasons outlined above, many more possible worlds, and therefore black boxes, can potentially be generated through the mental activity of interactive characters (see figure 13).

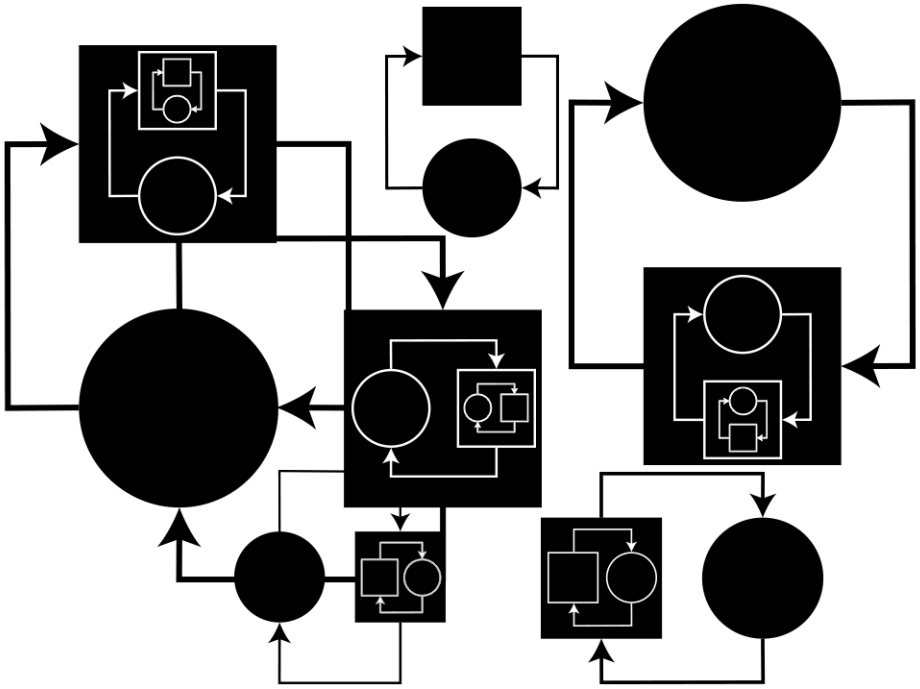

Figure 13. A snapshot impression of the black boxes of the characters within the story

The black box of the reader-player 'in character' (see figure 14) does not have a direct correspondence in Eco's schema of possible worlds. In *Stitched Up,* when the reader is playing as either protagonist, Joel or Sarah, they make choices on their behalf. Like an actor playing a part, while they are 'in character', the reader is making the character's decisions based on what the character knows, not what the reader knows (which may be more or less than the character at different points in the story). On the other hand, there is much that the reader-player needs to discover about the 'private universes' of all three main characters, including the protagonists, as they steer a course through the narrative and, as in life, even past histories and memories, can be susceptible to revision.

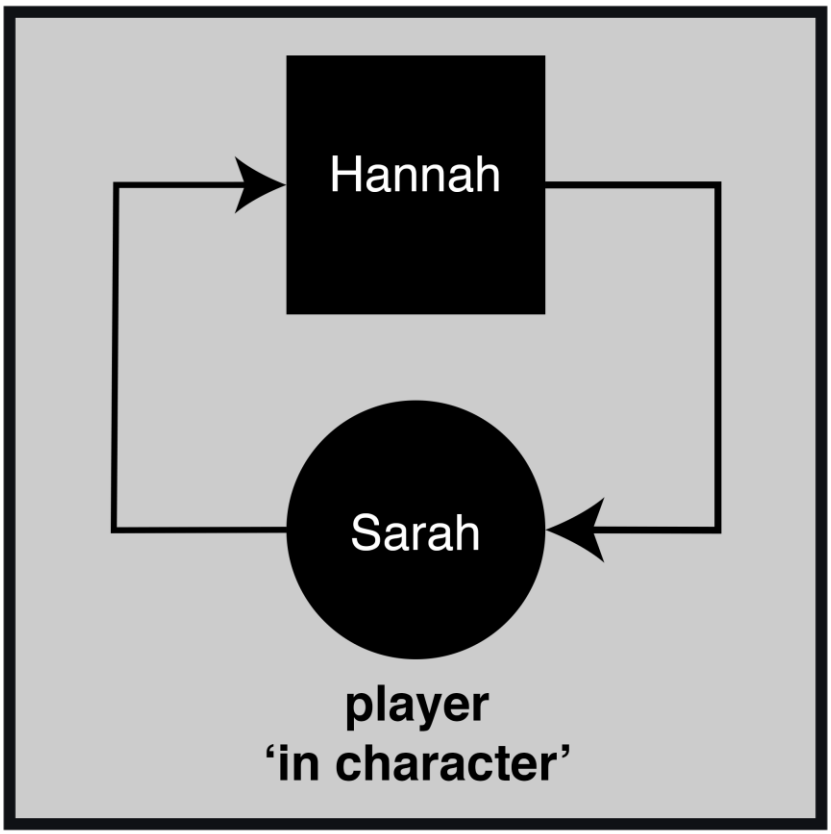

Figure 14. Black Box of the reader-player 'in character'

Ryan points out that the "motor that operates the narrative machine is the attempt by characters to eliminate conflict by reducing the distance between their model worlds and the actual world" (2013, para. 17). A state of conflict exists when a character's private world - the way they see things and what they want - is not satisfied in the (textual) actual world, or when it clashes with another character's model world. This is where a conceptual black box can come into play in an effort to work out what to do or a strategy. Employing Theory of Mind skills, the reader introduces conceptual black boxes onto these messy gap-ridden worlds of conflicting emotions, motives, memories, desires and intentions. Thus they have a way of surmising what the characters want and how to achieve their goals and/or thwart those of the antagonist. The story-playable challenge is in arriving at 'functional descriptions' of the characters' black boxes - e.g. "Ah! Hannah's doing/saying X because she wants Y, therefore Joel/Sarah should say A rather than B". How long these inferred explanations remain valid is an aspect of the gameplay and playability of the narrative.

The reader-player investigates these black boxes ‘in character’, playing as Joel or Sarah inside the story. I envisage this as an attractive feature of narrative gameplay because, as Zunshine proposes, "our enjoyment of fiction is predicated--at least in part--upon our awareness of our 'trying on' mental states" (2006, loc. 327). But the reader-player is also an observer or investigator (outside the story) of the black box of the story as it dynamically unfolds based on their choices.

This brings me to **the black box of the reader-player outside the story** (see figure 15) which corresponds to the possible worlds of the reader outside the *fabula* in Eco’s schema - i.e. what the Model Reader imagines, believes or desires, "the dynamic unfolding of the story in the reader’s mind" (Ryan, 2013, para. 14). The reader-player is self-aware, they are aware that they are playing a part, and they will have their own desires and ideas about what they want to happen, what they think might happen and what they think other character’s motives and intentions might be, and so on.

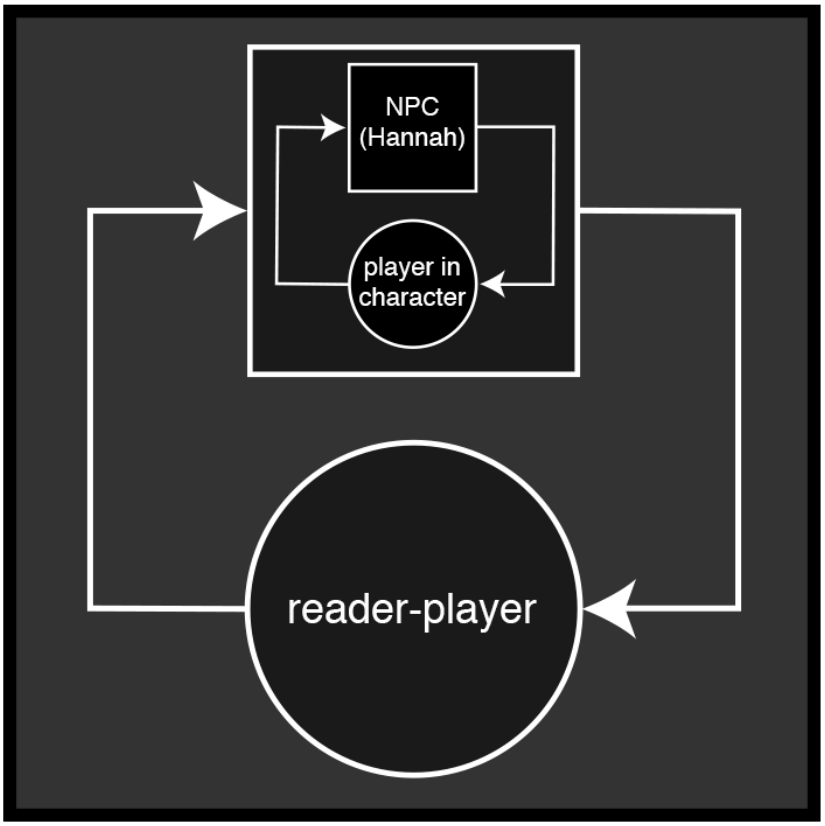

Figure 15. Black Box of the reader-player outside the story

> Trying to establish what holds as fact in the actual domain of the narrative universe, distinguishing the factual and physical from the possible and virtual located in the mental representations of characters, and building an image of these mental representations as a way to grasp the human significance of physical events and actions are some of the most fundamental of the cognitive operations that lead to the construction of narrative meaning.
> (Ryan, 2013, para. 17)

Again, Ryan's account of how the reader constructs narrative meaning bears a striking similarity to Glanville's idea of how the observer constructs a functional description of something they want to understand by inserting a black box on the mess they see initially, thereby giving order and form to it. It also relates to another aspect of Theory of Mind: metarepresentation.

> Sometimes described as "a representation of a representation," a metarepresentation consists of two parts. The first part specifies a source of representation, for example, "I thought . . . ," or "Our teacher informed us. . . ." The second part provides the content of representation, for example, ". . . that it was going to rain," or ". . . that plants photosynthesize."
> (Zunshine, 2006, loc. 883)

How far we regard the content of the second part of the metarepresentation as fact or true, even if provisionally, depends on how far we trust the source. We mentally tag the source of the representation and try to keep track of our tags so that, if we later find out that the source is unreliable, we can reassess the truth-value of the representation/s from that source. When reading fiction, we garner much information from our mind-reading of characters. "The ability to keep track of who thought, wanted, and felt what, and when they thought it, is crucial considering that the majority of our fictional narratives, ... center on the characters' reweighing the truth-value of various cultural and personal beliefs" (Zunshine, 2006, loc. 1131). *Stitched Up* is no exception. Indeed, as I will discuss later (in Reflections and Conclusion), keeping or losing track of source tags is part of the narrative gameplay.

1.6 Cybernetics and the Art of Steering an Interactive Narrative

"The narrative potential of an interactive text is a function of its underlying structure" (Ryan, 2015, loc. 3172). In this section, I discuss how cybernetics has influenced the interactive narrative structure of my *Conversengine* and what's unique about it. I also briefly review how it compares to other interactive digital narrative structures.

Cybernetics vs. AI

Cybernetics is "a science of goals, interaction, and feedback" (Dubberly & Pangaro, 2010, p. 2). Second-order cybernetics takes the observer or investigator of the goals, interaction and feedback into account as an integral part of the system (e.g. Glanville's black box, see above). Therefore it is a science of observing systems and it can be applied or identified in many different disciplines - for example, the scientific method, engineering, clinical practice in medicine, communication in psychology, learning models in cognitive science, using evidence to support conclusions in law, the quality cycle in management, ecosystems, human-computer interaction, and the design process (Pangaro, 2014, pp. 20-24 & pp. 113-114). Indeed, Pangaro claims that cybernetics is "a science for design" (2014, p. 4).

Cybernetics and Artificial Intelligence have been closely associated over the years and have often been confused but they are not the same thing.

> Researchers in Artificial Intelligence (AI) use computer technology to build intelligent machines; they consider implementation (that is, working examples) as the most important result. Practitioners of cybernetics use models of organizations, feedback, goals, and conversation to understand the capacity and limits of any system (technological, biological, or social); they consider powerful descriptions as the most important result.
> (Pangaro, 2013, para. 16)

I take the latter cybernetic approach to interactive digital narrative, rather than one that foregrounds Artificial Intelligence, as in the work of Mateas and Stern (2005), Chris Crawford (2012) or the Spirit AI team (2019) for example. I'm interested in how the

'powerful descriptions' derived from cybernetic models can inform or influence interactive narrative design and, in particular, how the relationship between the reader-player and the interactive narrative operates as a cybernetic process or 'observing system' (and the role of Theory of Mind in this).

Cybernetics: the Art of Steering and *Stitched Up*

The word 'cybernetics' comes from the Greek 'kybernetes' meaning the art of steering. "A steersman reacts to wind, tide, and other disturbances, correcting these 'errors' to keep his ship on course" (Dubberly & Pangaro, 2015, p. 4). The art of steering a ship towards a goal operates as a circular causal system or negative feedback loop, which has three phases: comparing, acting and sensing (see figure 16).

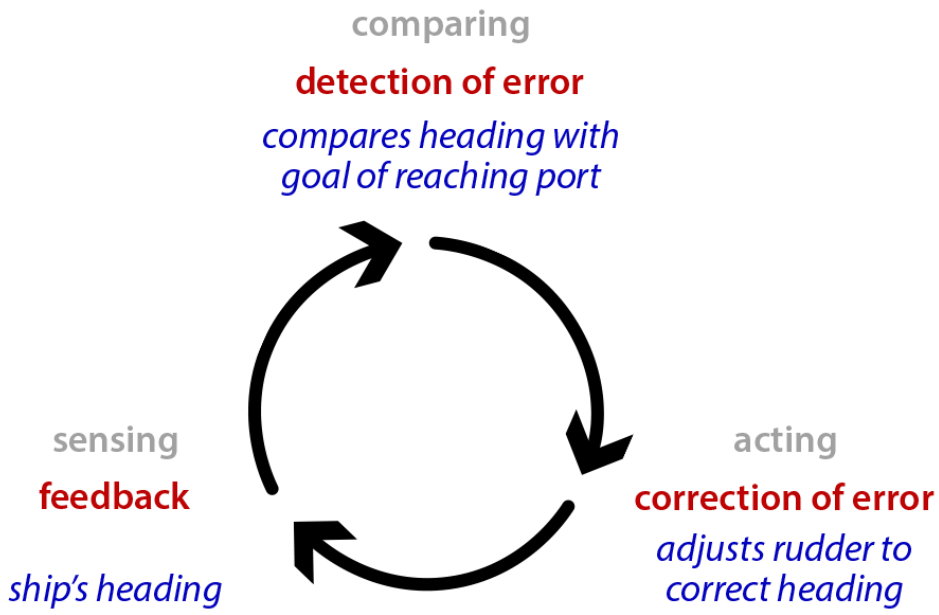

Figure 16. Steering: a circular causal system or feedback loop (based on Pangaro)

Comparing is the error detection phase, when the person steering compares the ship's heading or direction with their goal of reaching the port.
Acting is the error correction phase, when they adjust the rudder to correct the heading.
Sensing is the feedback phase, the ship's (new) heading or direction.

A cybernetic system always has some form of goal that it's aiming towards but environmental factors affect the aim. This is detected from information that returns to the system as feedback. The system measures the difference between its current state and the goal, and any difference is detected as an 'error', so the system acts to correct the error to achieve its goal.

In *Stitched Up*, the protagonist, which includes the reader-player *playing as* the protagonist, has a goal, which can be long-term (e.g. find Joel, escape captivity) or short-term (e.g. avoid immediate threat). The antagonist (non-player character) or story environment affects the protagonists' aim towards their goal in the form of narrative information which returns to them as feedback (from the narrative and/or interactive system). Therefore, the protagonist (including the reader-player) makes decisions and adjusts their course of action hoping to achieve their desired goal. Table 3, below, shows how the characteristics of cybernetics apply to *Stitched Up*, as a specific example of an interactive digital narrative (IDN) based upon these principles.

Cybernetics *(Pangaro, 2014, p. 12)*	***Stitched Up* IDN**
system has goal	player-protagonist* has goal
system aims toward goal	player-protagonist aims toward goal
environment affects aim	NPC** and/or story environment affects aim
information returns to system - ‘feedback’	information returns to player-protagonist - ‘feedback’
system measures difference between state and goal - detects ‘error’	player-protagonist measures difference between their state and goal - detects ‘error’
system acts to correct the error, to achieve its goal	player-protagonist acts to correct the error, to achieve their goal

* player-protagonist = shorthand for the reader-player *playing as* the protagonist
** NPC = non-player character

Table 3.

Therefore, the cybernetic feedback loop has directly influenced how I've designed the system for navigating through the multi-linear narrative of *Stitched Up*. That is, the reader-player engages in the 'art of steering' the narrative course. Here is how the negative feedback loop operates within my interactive digital narrative (see figure 17):

Comparing: the reader-player compares the protagonist's current state with an immediate or overall narrative goal.
Acting: the reader-player acts by making a choice (on behalf of the protagonist), for example, to say one thing, not the other.
Sensing: the reader-player/protagonist experiences feedback via the reaction/s of the fictional character/s (the protagonist experiences feedback from the non-player character, the reader-player experiences feedback from both characters).

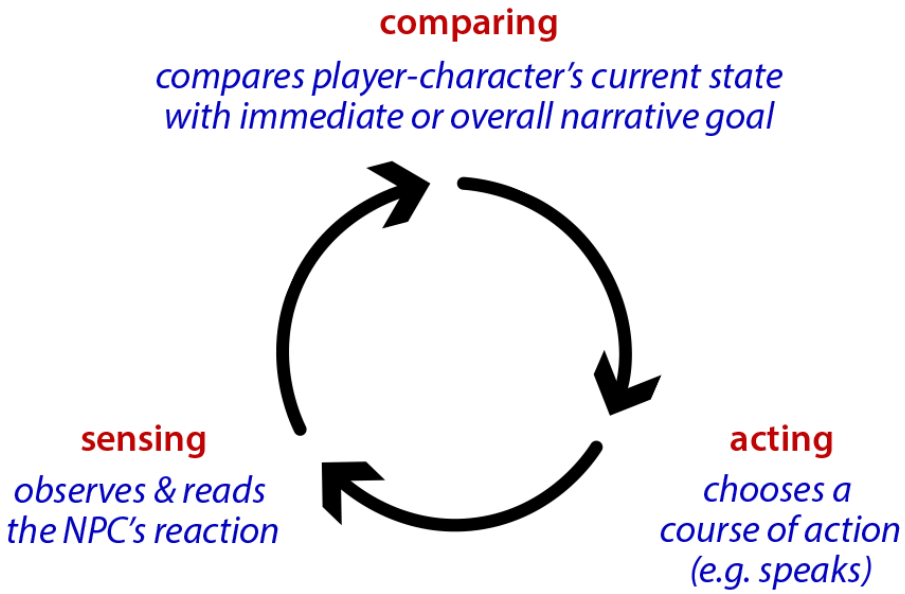

Figure 17. the feedback loop in *Stitched Up*

Feedback: emotional data visualisations

As the reader-player navigates the interactive narrative system of *Stitched Up* they receive continual feedback. But there will be no heads-up displays (HUD) in the public-facing *Convoplayer*, no visible statistics or scores in *Stitched Up*. Feedback arrives via

the fictional characters' diegetic responses, which come in two forms: text and animated visuals. Text conveys the characters' speech and, in the case of protagonists, their thoughts too. The visuals show their emotional reactions (which may sometimes be at odds with their words) by way of dynamic abstract data visualisations of their internal emotional states (more on this sections 1.4 and 1.5). In the same way that non-verbal communication has a powerful influence in human-to-human interaction, my reactive graphical user interface (GUI) communicates expressively via non-verbal feedback. This helps make my interactive characters seem alive, responsive and psychologically complex. The combined outputs of text and visuals will affect the choices that the reader-player makes, which are the inputs of the circular causal system. The emotional feedback from the characters is equivalent to the effects of the wind and tide buffeting a vessel. The reader-player is like the pilot of ship, relying "on negative feedback to steer a system toward a goal" (Dubberly & Pangaro, 2010, p. 21) but, in this case, they must steer a course through the stormy seas of emotion, trying to aim for a safe port of narrative resolution (compare figures 18 and 19).

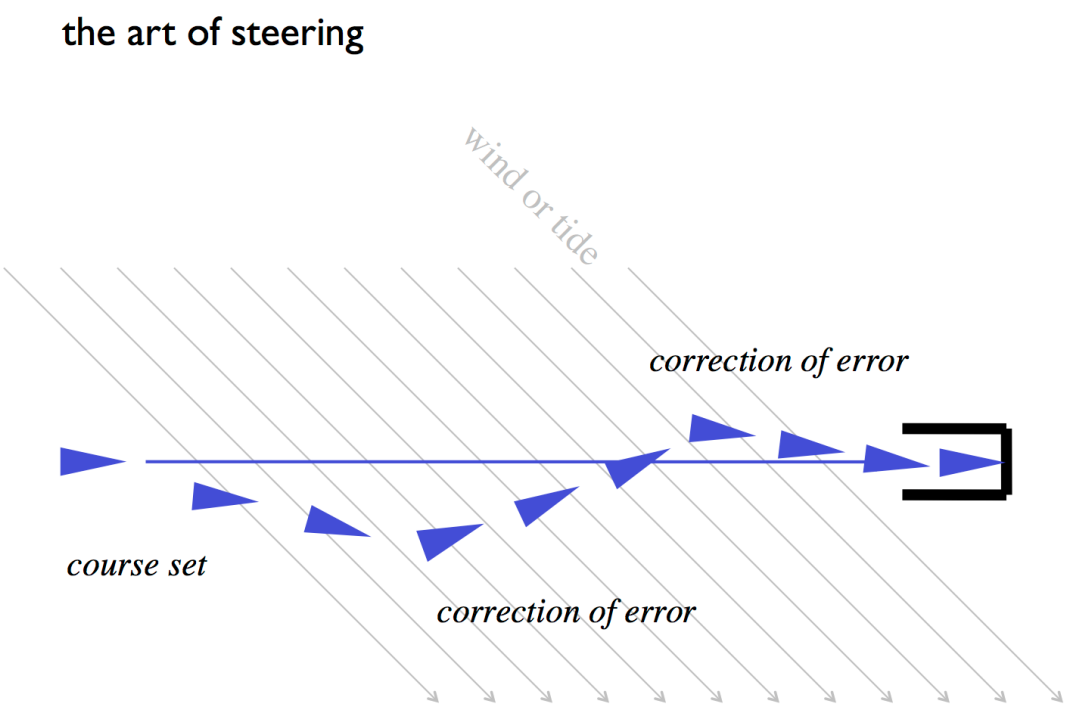

Figure 18. 'the art of steering' by Pangaro

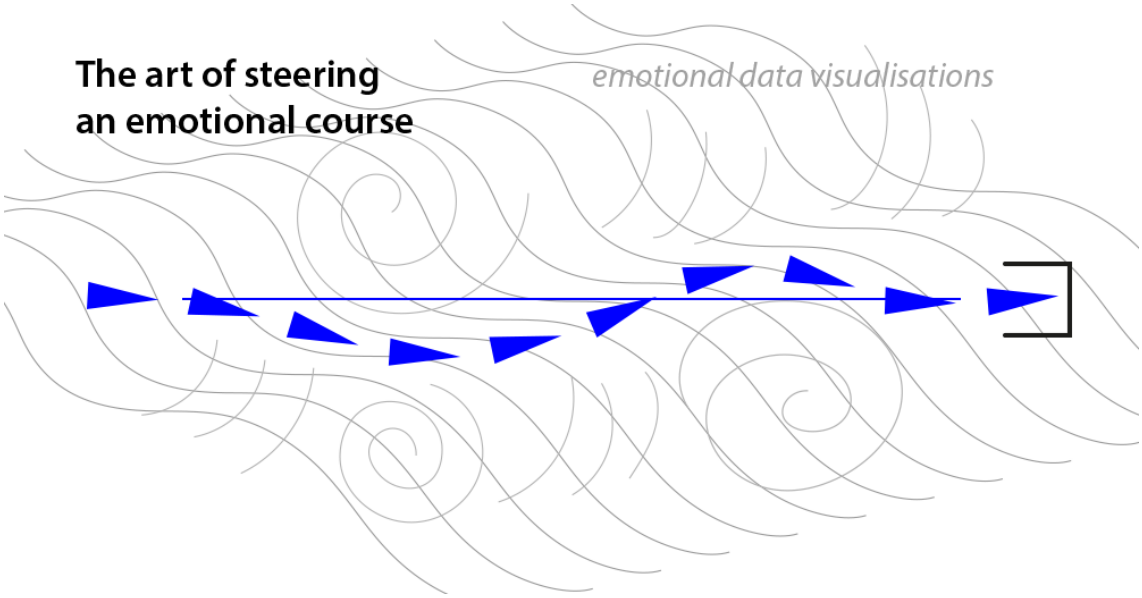

Figure 19. the art of steering an emotional course

Steering a Course Through the Narrative

Under-par, Optimum, Overkill courses

As author, my task is to create the potential for the reader-player to negotiate a coherent course through the multiplicity of narrative possibilities. I achieve this by creating three notional base courses through the narrative - notional in the sense that each course could, in theory, be followed exactly and completely but that would be unlikely to happen in practice.

Here's how I characterise the three notional base courses through the narrative of *Stitched Up*:

Overkill course = a story of retribution;
keyword: aggressive;
characterised by: vengeance, anger, blame, violence or violent thoughts, attacking, domination, recklessness, rebellion, rejection, pessimism, hate.

Optimal course[7] = a story based on understanding;
keyword: active;
characterised by: listening, seeing another's point of view, non-compliance, resistance, resilience, questioning, being realistic, evidence-seeking, optimism, hope, forgiveness, love.

Under-par course = a story of losing hope;
keyword: passive;
characterised by: fear, running away, paralysis, submission, giving up, self-blame, shame, fatalism, pessimism, hopelessness, despair.

Character development and steering a course

As discussed previously (in section 1.2), Forster (1927) regarded character development as one of the defining features of round characters. Although, as Rimmon-Kenan (2003, p.56) showed, a complex character can be static (e.g. Dickens' Miss Havisham), it is more common to find (or construct from the text) life-like psychological depth in a character that develops (emotionally, intellectually or socially). Such a character is likely to be, in Fishelov's terms, a "'Pure' individual" (1990, p. 426), round or complex on both the textual and constructed levels. Also, as Yorke argued, character development is "inevitably linked to dramatic structure" (2014, p.136) and, as I have argued (see section 1.0), thinking in terms of dramatic structure is highly appropriate for an interactive narrative, such as *Stitched Up,* with no narrator.

In *Stitched Up*, each of the main characters develops differently depending on which course the narrative takes. Below, I present broad-brush descriptions of how Sarah and

[7] Although I have named one of the notional courses the Optimal course this should not be confused with the idea of the 'Critical Path' in conventional videogame design. The Critical Path is "The path the player is expected and encouraged to follow when moving through a game or a particular level. Somewhat reminiscent of the yellow brick road in The *Wizard of Oz*" (Rouse III, 2004). In *Stitched Up*, there is no privileged course, indeed, changing tack is a defining feature of the system. My intention is that any course steered through the narrative should offer a satisfying narrative experience. Optimal, in my scheme, simply means that steering a more or less Optimal course will lead to more positive outcomes for the protagonists.

Joel develop. Hannah's character also develops but not as radically as the protagonists. Unfortunately, it's difficult to discuss character development without giving too much away but, in what follows, I try to avoid spoilers. In all courses of the narrative, a disturbing revelation emerges about how their haphazard Victorian house renovations may have contributed to Sarah's multiple miscarriages. This is a key turning point. In general terms, the course the story takes depends on how far Sarah and Joel are swayed and misled by Hannah or how far they resist her malign influence.

Overkill course

Sarah, under Hannah's influence, is convinced of Joel's infidelity and views it in the worst possible light. She blames him for all that's wrong in their marriage, including her multiple miscarriages, which she believes were the result of his hands-on obsession with renovating their old Victorian house. Motivated by anger and bitterness, she persists in her search for Joel with vengeful determination.

Joel is wracked with guilt - initially, about his one-off infidelity but, later, also about the probable effects of the house renovations on Sarah's failed pregnancies. His sense of shame turns into anger and bitterness, which he turns towards Sarah, blaming her for the cracks in their relationship, which Hannah encourages. He deludes himself about his abilities and future (even to the extent of imagining he would be better off with Hannah).

Optimal course

Sarah persists in searching for the truth, trying to understand and make sense of things. She decides that, no matter his mistakes, she still loves Joel. In the teeth of opposition from Hannah, she maintains her capacity to forgive. She is determined to find Joel and try to make their marriage work, which means recognising her own flaws and taking her share of responsibility for their marital problems.

Joel feels genuinely remorseful about his lapse in fidelity, his carelessness regarding the house renovations, and his lack of sympathy and understanding for Sarah's distress. As Hannah's prisoner, he struggles to see through her lies and distortions but manages to

maintain self-awareness. If worse comes to worst, he's prepared to sacrifice himself for Sarah.

Under-par course

Sarah is too fearful of being less than perfect, of feeling a failure. She's not sure that she loves Joel anymore but feels she's running out of time to start a family so she'd better bear with it and find him, rather than start over, looking for someone new. Eventually, under Hannah's influence, she may lose all hope and abandon her search for him.

Joel is overwhelmed by guilt and feels he's a terrible person. He doesn't deserve Sarah, doesn't deserve to be a father, to have a family. No wonder he's suffering now, being punished. Hannah foments his self-flagellation. Despairing, Joel succumbs to her twisted dichotomous thinking.

Steering…

The three base courses are notional in the sense that each is a course the reader-player would take if their choices were consistently of type Overkill, Optimal or Under-par, which would be improbable. It is more likely that the reader-player will feel more inclined to choose one type of response or another at different points in the narrative, depending on numerous factors, including whether or not they empathise with the protagonist at the time and how they interpret what is going on in the narrative, what the characters' motives, mental and emotional states might be. In other words, the narrative turning points where the reader-player must make a decision will engage their Theory of Mind and their choices will be contingent upon the possible worlds they construct for the fictional characters - which is also to say, in my scheme of things, contingent upon what kinds of black boxes the reader-player constructs. As they progress through the narrative, the reader-player will be continually engaged in a conceptual activity of inserting black boxes to try to make sense of what's happening. This is a highly dynamic process because, at any given time, the status of any narrative black box can be open to question. Since black boxes are likely to involve metarepresentations, the reader-player will be trying to keep track of source tags (e.g. "Hannah claims that...", "Under duress,

Joel admitted..."), continually weighing and re-weighing the truth-value of those representations.

The causal steering pattern is recursive, it works at the macro narrative level, the scene by scene level and also at the moment by moment (or beat by beat) micro level of the dialogue within a scene. At the end of each scene an algorithm calculates an overall Overkill / Optimum / Under-par performance value for the scene and this determines the course of the next scene and/or, crucially, has a cumulative effect downstream in the narrative. I expect most reader-players will change tack frequently from one course to another as they progress through the narrative, although they may show bias towards a particular course. (Without substantial play-testing, I can only offer conjecture at this stage.)

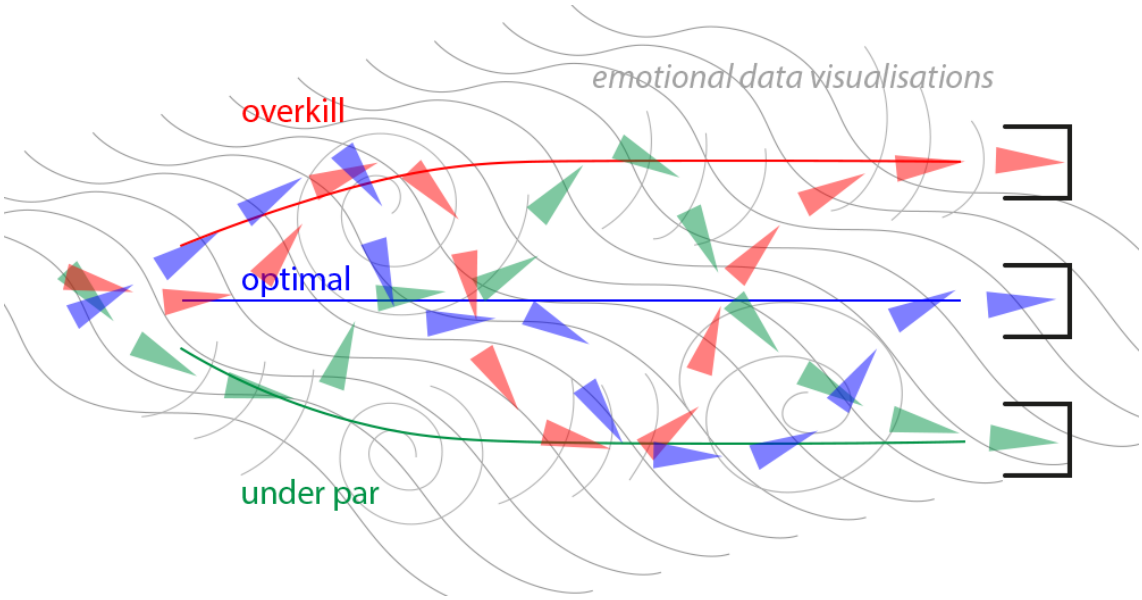

Figure 20. Steering and changing tack

This changing-tack stimulus-response model, which is my core gameplay loop, functions as a kind of rudder for the reader-player to steer a course through *Stitched Up*'s narrative universe of possible worlds and black boxes. How the reader-player chooses to interpret the characters' behaviour will determine the kind of story they experience and its outcome.

Other interactive digital narrative structures

The steering-a-course interactive narrative structure of my *Conversengine*, which drives *Stitched Up*, is unique but does bear some similarities to other interactive digital narrative (IDN) structures. Several IDN authors and theorists have identified a variety of ways that choice-based interactive narratives (also known as branching narratives, Choose Your Own Adventure or hypertexts) can be structured (see: Miller, 2008; Fabulich, 2011; Kennedy, 2012; Ashwell, 2015; Ryan, 2015; Short, 2016a, 2016b; Rickerby, 2016, 2019). Predominant concerns include issues of player agency, narrative coherence and avoiding or managing the potential combinatorial explosion of unfettered branching narratives. According to Fabulich, "The solution to this [latter] problem is to use *delayed branching*, in which earlier choices don't branch the story right away; instead, they determine the outcome of later decisions" (2011, para. 6). In *Stitched Up*, I use delayed branching at the macro scene level, however, at the micro level, within a course within a scene (see figure 21), there can be branching at any point. This is similar to one of the small-scale structures identified by Short, "Track Switching Choice" (2016b, para. 6), which allows the player a degree of vacillation. Ryan identifies "The directed network, or flow chart" as an interactive structure that "represents the best way to reconcile a reasonably dramatic narrative with some degree of interactivity" (2015, loc.3269) and this bears a passing resemblance to mine. These IDN structures have influenced my own design to some extent but, mainly, they have served to confirm my design choices.

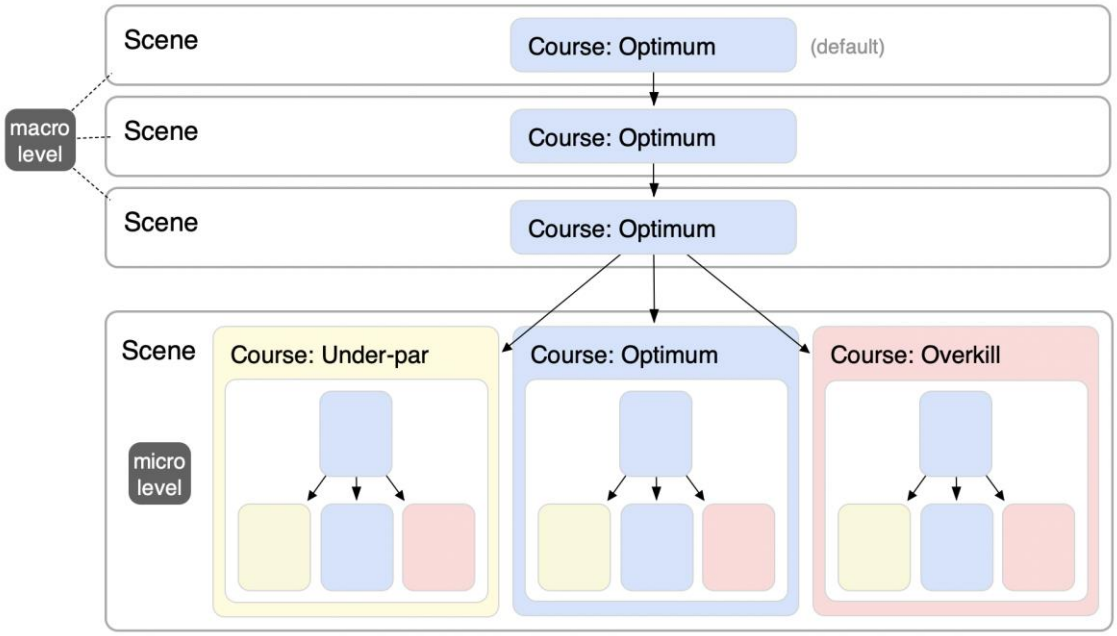

Figure 21. Diagram of *Conversengine* scenes at the macro level and nested *courses* at the micro level

1.7 Modelling Emotions

In a psychological thriller, the interior lives of the characters and their interpersonal relationships are more important than exterior action and adventure. So, for *Stitched Up*, I am developing a dynamic form of visual 'language' that is able to represent fictional characters, along with their words, as abstract visualisations of their internal emotional data. I call this my *emoviz* system and it entails encoding emotions as digital data, then translating the emotional data into expressive animated graphical forms that represent the fictional characters. Currently, this visual emotional language system, or emoviz apparatus, is at an early proof-of-concept stage.

The Power of Visualisations and Abstractions

It's common in the vast majority of graphic interactive stories and videogames to represent characters figuratively but I've chosen to render mine as abstract visualisations of data. There are some pragmatic reasons for this. It makes the interactive digital fiction much less voracious in terms of digital assets, computer processor and human developer resources. This allows development to be more agile, which, in turn, means

much greater flexibility in story and character creation. Also the resulting artefact is more suitable for web delivery (publishing) on mobile platforms. But the more important reasons are artistic.

Abstraction avoids the objectifying gaze of the virtual camera, which so often amplifies stereotypical gender representations in videogames (which I discuss more fully in section 2.3). The majority of video-games tend to be concerned with the surface of things, external action and/or simulating ‘real world’ effects (e.g. 3D objects, Newtonian laws of motion). I'm more concerned with the internal forces that motivate a character's actions rather than the external forces of cause and effect that dominate so many playable adventures and action-based video-games. I am more interested in modelling fictional minds; which is why the work is text-based because, as the novel exemplifies, written fiction can engage the reader's Theory of Mind (Palmer, 2004; Zunshine, 2006), making text highly suited for this creative purpose. But an interactive digital fiction needs some form of user interface to facilitate interactivity. If it's a graphical user interface, a visual dimension is inevitable and, as a creator, I strive to make my work expressive in every modality.

In *Chris Crawford on Interactive Storytelling,* the author argues that it's not important for interactive characters to look like the real thing, he says, “the *sine qua non* of interactive storytelling is that the characters ***act*** like the real thing.” Therefore, the “core of the models we create for interactive storytelling lies in their behaviour” (Crawford, 2012, loc. 2711).

I want my graphical user interface to communicate eloquently via non-verbal feedback, as well as text, to deliver subtextual layers of meaning. The obvious thing would be to illustrate characters’ facial expressions. For example, Crawford used a "facial display system" in *Siboot*, his "game about social intelligence and emotional intuition" (2017, no longer available). In a video lecture about it he says he's “developed a technology for faces with dynamic emotional expressions but I have to admit it’s really primitive” (Crawford, 2017, no longer available).

Rather than using figurative graphic techniques, I prefer abstraction as a means of conveying emotion (likewise, de Rooij, Broekens and Lamers, 2013). Indeed, I propose

that visual abstraction, in the right context, may have more nuanced expressive potential than illustrative representations, whilst still maintaining a high degree of intelligibility. Consider data visualisations, which have been described "as an intersection of art and science" (Kirk, 2012, p. 22). The internet is teeming with them and many are interactive and highly responsive to continually changing real world data sources. Despite being abstract, they are also highly readable, which is precisely their point. "One of the great strengths of data visualization is our ability to process visual information much more rapidly than verbal information" (Few, 2013, para. 30). Because the brain is tuned to process particular attributes of visual information, "such as differences in length, size, hue, color intensity, angle, texture, shape, and so on," when these features are exploited purposefully in a visualisation, the result is "more efficient cognition" (Few, 2013, para. 30).

> From a psychological perspective abstraction refers to a complex of processes that facilitate the ability to dismiss the irrelevant and focus on essential information only, which is a fundamental operation that is applied at many levels of cognition and perception (Barsalou, 2003; Hampton, 2003; Zimmer, 2003).
> (de Rooij, Broekens and Lamers, 2013, p.3)

There are two common types of data visualisations: exploratory, for data analysis and discovering "significant, meaningful patterns in data"; and explanatory, for communicating "only the important points" in a data set (Murray, 2013, p. 8). But my emotional data visualisations (emoviz) are neither explanatory nor exploratory. *Expressivity* is the key quality I need for the purpose of dramatising the fluctuating emotions of fictional characters'.

Abstraction is an important part of the semantic repertoire in both art and science. For example, it's a core concept in computer science:

> *An abstraction focuses on the essential attributes of the subject, removing any unnecessary details from the user*. But what constitutes the essential parts depends on the perspective from which you view the abstraction.
> (Ghosh, 2011, p. 22)

In a typical data visualisation, what constitutes the essential parts is primarily a functional choice, informed by the data source. But in a creative work, it's an aesthetic choice, for example:

> When we *abstract* an image through *cartooning*, we're not so much *eliminating* details as we are *focusing* on *specific details*. By *stripping down* an image to its essential '*meaning*,' an artist can *amplify* that meaning in a way that realistic art *can't*
> (McCloud, 2001, p. 30)

So, while I'm influenced by the art and science of data visualisation, I use artistic license wherever appropriate. However, my emoviz system is still a work-in-progress and I remain open to exploring how far I can ground my visualisations in cognitive science and psychology.

Emotions as data

My interactive narrative requires developing an underlying data model for my characters' emotional lives and, not only finding an appropriate way of representing that data, but finding a way of representing each different character's unique emotional data in a way that differentiates one character from another (and eventually, in future iterations, can express their individual personalities).

Since I'm writing in computer code, as well as natural language, I need to find a way of expressing emotions as numerical data. Some might think it "absurd to represent characters mathematically" (Yorke, 2014, loc. 2218), and it may seem bizarre in the fields of art and literature, but in the field of science, especially psychology, it's not uncommon. Just as data visualisation combines art and science (Kirk, 2012, p. 22) so does interactive storytelling, which combines narrative and multimedia arts with computer science and Human Computer Interaction, which also utilizes models from psychology and cognitive science.

Discussing the basics of interactive storytelling, Crawford says, "A computer model has two fundamental types of elements: variables and equations. The variables are numbers that specify what's important about the model. The equations use the variables to

calculate useful things" (2012, loc. 2723). Therefore numerical data models borrowed from other fields can be particularly useful when designing and constructing interactive narratives and other kinds of digital creative works. Since I need to design and construct my interactive characters in such a way that they include or consist of systems of data that can be represented as visualisations, finding an appropriate measurement scale to express emotions as data variables that can be used in equations or functions is crucial.

Therefore, I turn to the field of psychology for their expertise in systems for measuring emotion. After all, "An essential requirement of any integrated science is the availability of a few basic dimensions suitable for analyses of all its problems" (Mehrabian, 1996, p. 261).

Pleasure Arousal & Dominance (PAD)

The psychological model I've chosen to use is the Pleasure-Arousal-Dominance (PAD) Emotional State Model, developed by Russell and Mehrabian (1977)[8]. The PAD model uses "three independent and bipolar dimensions, pleasure-displeasure, degree of arousal, and dominance-submissiveness," which they found were "both necessary and sufficient to define all emotional states" (Russell & Mehrabian, 1977, p. 273). I was attracted to it because the following description of PAD could equally serve as a description of the entire dramatic emotional space that could be traversed in *Stitched Up*.

> The three dimensions are defined as bipolar such that pleasure is a continuum ranging from extreme pain or unhappiness at one end to extreme happiness or ecstasy at the other end. Arousal ranges from sleep through intermediate states of drowsiness and then alertness to frenzied excitement at the opposite extreme. Dominance ranges from feelings of total lack of control or influence on events and surroundings to the opposite extreme of feeling influential and in control. According to these definitions, "emotion" does not merely include occasional passionate states. Rather, a person is viewed as being in some emotional state at all times, a state that can be described as a region within a three-dimensional space.
> (Russell & Mehrabian, 1977, p. 274)

[8] The model was initially called "Three-Factor Theory of Emotions."

The PAD Emotional State Model has been applied in diverse fields, including emotion-oriented computing and videogames (Broekens & Brinkman, 2013; Pena *et al.,* 2011; Yang & Min, 2013). Some researchers, for the sake of simplicity, prefer to concentrate on just two of the bipolar dimensions, pleasure (P) and arousal (A) (e.g. Yang & Min, 2013). However Russell and Mehrabian insist that dominance (D) is necessary as a basic factor too because, "Only dominance makes it possible to distinguish angry from anxious, alert from surprised, relaxed from protected, and disdainful from impotent" (Russell & Mehrabian, 1977, p. 292). Considering the nature of my story and characters, the third dimension of dominance is of vital importance to my project too.

According to Crawford, "A personality model for interactive storytelling must meet four crucial criteria: It must be complete, concise, and orthogonal, plus the personality traits must naturally imply behavior" (2012, loc. 3262). Using the PAD Emotional State Model would fulfil all these criteria. Firstly, the model is expressly designed to be complete and, secondly, concise, and thirdly, it is orthogonal in that the three bipolar dimensions of PAD "are independent in that any value along one dimension can occur simultaneously with any value on either of the other two dimensions" (Russell & Mehrabian, 1977, p. 274). Fourthly, employing an emotional state model naturally implies behaviour. This suggests that the Pleasure-Arousal-Dominance bipolar dimensions would be well suited for modelling my characters' emotional lives in code and, indeed, I will not be the first to have used the model in this way (see Yang & Min, 2013).

More support for the potential utility of the PAD model for my project comes from the AAAC (Association for the Advancement of Affective Computing), which grew out of the EU-funded network of excellence HUMAINE, and involves many disciplines in research into emotion-oriented computing. "Description of Emotion" is one of the thematic research areas of the AAAC since "Emotion-oriented computing needs tractable ways of describing the states that matter to it" (HUMAINE Association, 2008a, para. 11). To describe emotions in technological systems, the AAAC has proposed an Emotion Annotation and Representation Language (EARL), which also focuses on three dimensions:

> The most important dimension is related to a valenced evaluation in terms of positive vs. negative, pleasurable vs. unpleasurable. The second dimension is usually related to the overall state of activity or arousal, from active to passive. The third dimension, which is slightly less frequently used, is related to the degree of control or social power that an individual has in a situation, i.e. high vs. low control or, when the focus is on the social relationship, dominant vs. submissive.
> (HUMAINE Association, 2008b, para. 6.2)

The EARL naming convention differs - they use Valence, Arousal and Power - but their dimensions map directly to the Pleasure-Arousal-Dominance dimensions of the PAD model.

Interestingly, in his character model, although Crawford places more emphasis on personality traits than emotions (which he calls moods), he also finds three bipolar dimensions sufficient for his needs: “I have tried many approaches to personality modeling. After all these experiments, I have come to the conclusion that a simple model with just three variables will handle most storyworlds” (Crawford, 2012, loc. 3390). His three variables are the personality traits: 'Nice_Nasty', 'Honest_False' and 'Wilful_Pliant'. As personality traits, rather than emotions, I would not expect these variables to map directly to the PAD dimensions but there does seem to be a clear relationship between Nice_Nasty and Pleasure, and between Wilful_Pliant and Dominance.

Crawford’s personality model takes account of “variable moods that characters are subject to” which “spontaneously change with time” - in other words, emotions. “Like personality traits, moods are bipolar and should be represented as two opposing forces, with the normal value being 0.0. Specific events can then push the mood in either a positive or a negative direction” (Crawford, 2012, loc. 3459). He uses four moods in his work: "Happy_Sad", "Aroused_Disgusted", 'Angry_Fearful", and 'Energetic_Tired", although he admits the latter is “a physical trait, not a personality trait, so it may not be of use in many storyworlds” (Crawford, 2012, loc. 3476). Because of the addition of this physical trait, it could be argued that Crawford is using a three-dimensional emotional state model. Once again, although they do not map neatly to the PAD dimensions, there is clearly a relationship between Pleasure and Happy_Sad, and

between Dominance and Angry_Fearful. Interestingly, the Arousal dimension from PAD could be viewed as having a correlation with both Aroused_Disgusted and Energetic_Tired. Since Crawford admits that Energetic_Tired is not a “personality trait”, therefore not an emotion, but that he sometimes uses it in the realm of emotion, I conclude that PAD is a clearer, more complete and concise emotional state model than his. It also further supports the argument that PAD is “both necessary and sufficient to adequately define emotional states” (Russell & Mehrabian, 1977, p. 273).

For these reasons, I employ the Pleasure-Arousal-Dominance Emotional State Model to configure and govern or modulate my characters’ emotional responses (see table 4):

Pleasure	<---------->	Displeasure
Arousal	<---------->	Non-arousal
Dominance	<---------->	Submissiveness

Table 4. PAD dimensions

Comparing PAD to other emotion models

To convert the PAD model into dynamic emotion visualisations, I needed to translate a wide range of emotions into configurations of numerical values. So I surveyed, compared and synthesised a variety of emotion models and classifications (Ekman, 1992; Ekman and Ekman, 2016; Valdez and Mehrabian, 1994; Mehrabian, 1996; Mehrabian, 2010; HUMAINE Association, 2008b; Parrott, 2001; Pena et al., 2011; Parrott, Plutchik quoted Wikipedia, 2019; Plutchik quoted in Wikiversity, 2019). See Appendix for a comparative table of this meta-analysis of emotion classification. I converted this data into PAD values, which I fed into my emoviz code, which transmuted it into animated visual qualities. Then I was able to experiment with ways of expressing a range of emotional states. You can see some results of this in the 'PAD emoviz' page of my Convowriter app, which is a dedicated area for experimentation. At present, these are proof-of-concept animations. I will enhance and refine their expressivity and emotional verisimilitude as I go on to further develop *Stitched Up* and

the *Conversengine*. The visualisations are also used to represent *Stitched Up*'s three main characters in the *Playtester*[9].

1.8 Emotional Visualisations: Colour, Shape and Motion

Character colour schemes in *Stitched Up*

Each interactive fictional character in *Stitched Up* is visualised onscreen in a contextual zone which distinctively represents that character, a dynamic visual field from which they ‘speak’, ‘think’ (protagonists only), and 'emote'. This serves as a trope for the character’s presence - their face, demeanour, tone of voice, etc. - so each main character has a distinctive complimentary colour[10] scheme (see figure 22) which uniquely identifies them:

Hannah: red (0º) and green (137º)
Joel: yellow (56º) and purple (259º)
Sarah: blue (200º) and orange (33º)

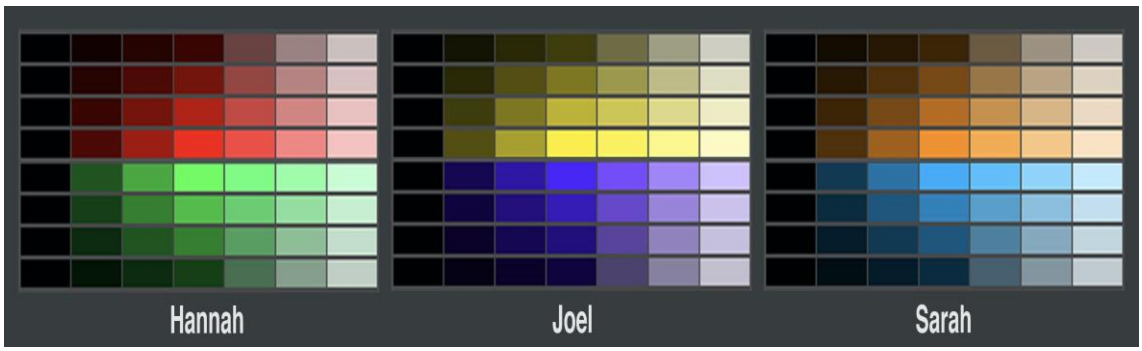

Figure. 22. Characters' colour swatches

[9] A section of the Convowriter for playing through scenes within the interactive narrative.
[10] The HSL colour model for the web encodes colours as three values: hue, saturation and lightness. A hue is given numerical value according to its position on a 360º colour wheel (Çelik et al., 2018).

Complimentary colours create the strongest contrast and reinforce each other when adjacent, creating an optical zing, which helps make the characters seem more alive - an aesthetic judgement on my part. Also the mid-point of a gradient between two complimentary colours is neutral grey. So, combined with variations in lightness and saturation, these features offer a wide expressive range from two very specific complimentary hues.

Notwithstanding that colour psychology is a moot area (see below), there is a rationale to my characters' colour palettes. Hannah, the antagonist, has red because it's commonly associated with anger, passion, blood, warning and danger. Its complimentary is green, which is apt because Hannah is a traditional upholsterer, steeped in the Victorian period when red and green were popular colours for interior decor (judging by my picture research collection on Pinterest[11]). Sarah, on the other hand, has blue to emphasise the contrasting natures of the female characters. Red and blue are often used in colour affect experiments because they are considered to have opposite effects (Lichtlé, 2007; Labrecque & Milne, 2011; Bagchi & Cheema, 2013). Joel has yellow and purple, a combination redolent of bruising.

Colour and Emotion

Colour is a vital part of any data visualisation, it is highly expressive and has long been associated with mood and emotion. Finding the appropriate colours to represent my characters and express their emotional states was absolutely crucial. The affects and meanings of colour have been studied in relation to fields as diverse as art, psychology, zoology, the design of environments, marketing, film and television, and game design, amongst others:

> Some colors are able to arouse and excite an individual, while other colors elicit relaxation. Research on color suggests hue (as in primary colors red, blue, yellow), brightness (light colors such as white versus dark colors such as black or gray), and saturation (intense versions of a color versus pastels) all have an effect on individual reactions and perceptions (Latomia and Happ, 1987).
> (Cyr, 2013, section 40.3.1)

[11] See: https://www.pinterest.com/crissxross/neo-victorian-aesthetic/

But nothing conclusive has been established about what particular colours mean or their affects: “First, while findings from research suggest that colour influences human response, the existence of an irrefutable and universal causal link between colour and an unlimited range of psychological, biological, and behavioral responses remains an unsupported hypothesis” (O’Connor, 2011, p. 232).

Colour and its effects are complex and, except in controlled experimental conditions, cannot be isolated from context. In the real world, many variables come into play: the effects of light; colour combinations; personal, cultural and cross-cultural associations, etc. (O’Connor, 2011). My use of colour in *Stitched Up* is guided by some commonly found associations and affects of colour (in Western cultures), but a creative work can establish its own internal context which can then generate its own particular range of meanings and associations. If I apply my colour-emotion model consistently and with dramatic purpose (congruent with relevant psychological research), the reader-player will quickly learn from the context to associate certain colour values or combinations with particular emotional responses or moods for individual fictional characters.

However, of particular relevance to my project are the findings of Valdez and Mehrabian (1994), who applied the Pleasure-Arousal-Dominance (PAD) Emotional State Model to the psychology of colour. They tested single colour samples (taken from the Munsell Color System) under controlled lighting conditions on 250 subjects (students), who rated the colours along the dimensions of Pleasure, Arousal and Dominance. Surprisingly, they discovered that hue alone had very little emotional effect (leaving me free to select characters' colour palettes for other factors, as discussed above), but they found "strong and highly predictable relationships of color brightness and saturation to emotional reactions" (Valdez and Mehrabian, 1994, p. 405). Specifically, they found that:

- **P** brighter and more saturated colours (especially brighter colours) are more pleasurable;
- **A** darker more saturated colours are more arousing;
- **D** darker more saturated colours (especially darker) are more dominance-inducing.

They stressed that context is important and noted that their findings support "the more intuitive groupings and interpretations of colors offered by practitioners of the arts" (Valdez and Mehrabian, 1994, p. 406). Therefore, and especially since colour combinations are vital in *Stitched Up*, I trust in my artistic judgement; but Valdez and Mehrabian's results are helpful and have influenced how I use colour to express emotion.

Colour is just one part of the equation in any data visualisation and my emoviz system needs to be especially expressive. It requires a whole range of visual attributes - colour, line, shape, texture, opacity, scale, motion - to be mapped to PAD dimensions (pleasure arousal dominance).

Here are some potential mappings that I came up with early on, selected intuitively (see figure 23).

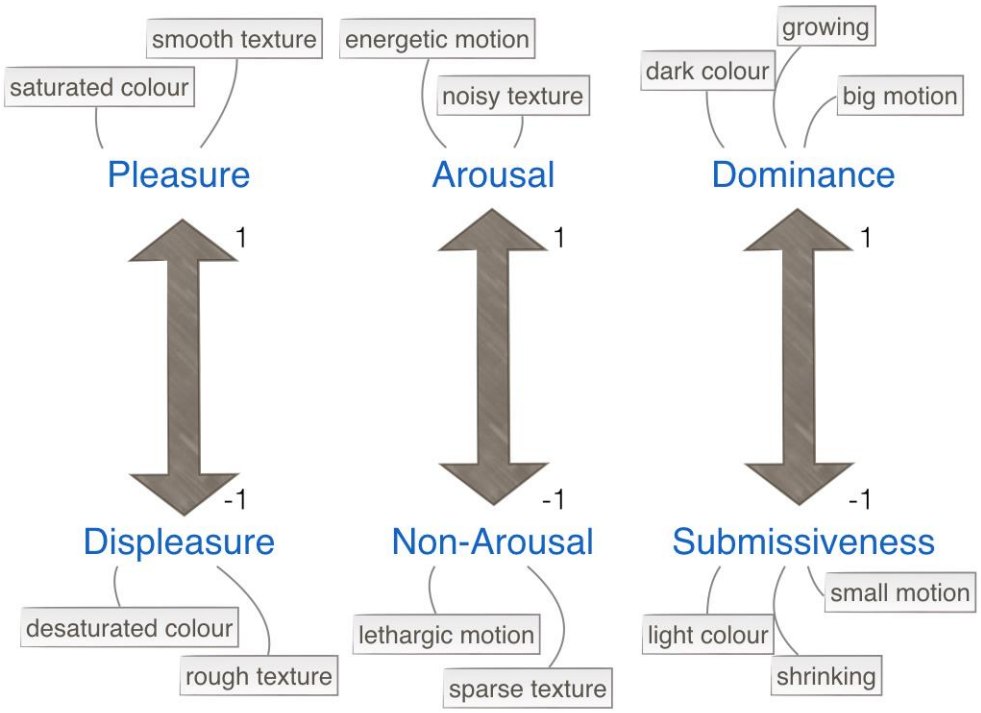

Figure 23. An early example of mapping visual attributes to PAD

If data visualisation is a mix of art and science, and both fields advocate experimentation, where to begin when developing original forms of visualisation? With the art or the science?

At first, I opted for a more intuitive artistic approach. The resulting creative experiments were expressive but they were predetermined linear animations. How would they plug into a programmable system where specific visual attributes are consistently associated with affective qualities that change dynamically as the character responds emotionally? I had to deconstruct the animations: isolating, identifying and quantifying their various different properties in order to map and bind them to one of the properties of the PAD system. Then, I had to test them against the quantified emotions of my fictional characters to see if they expressed what I imagined.

I started with colour brightness and saturation, applying the psychological data from Valdez and Mehrabian (1994). Although interesting, the results did not fully satisfy the expressive dramatic needs of my project. For example, if the colour properties they associate with anger represent an average subject's response, are they appropriate for a dramatic character who may be far more hot-headed? In such cases I yield to my artistic judgement and my detailed knowledge of my fictional characters.

Shape, Motion and Emotion

When considering which visual properties to map to which PAD dimension and how to animate them, visual metaphor and analogues are propitious. For example, consider line, shape and scale in relation to the following:

- curviness vs. angularity of line or shape mapped to pleasure-displeasure
- amplitude of line mapped to arousal
- size and scale of line or shape mapped to dominance

These correlations seem instinctively apt, even obvious (e.g. most of us are familiar with the ECG flatline from hospital dramas signalling death). So, I began experimenting with circles and rounded shapes to express pleasure (+P) and inverted triangles and angular shapes to express displeasure (-P). I was particularly heartened to discover that these intuitive choices are supported by the psychological scientific research:

> ...even very simple context-free geometric shapes have been shown to signal emotion. Specifically, downward-pointing V’s are perceived as threatening and

> curvilinear forms are perceived as pleasant... The present findings support the hypothesis that simple geometric forms convey emotion and that this perception does not require explicit judgment.
> (Larson, Aronoff and Steuer, 2012, p. 404)

A number of other studies concur, finding that simple shapes affect emotional responses and, specifically, that downward triangles are perceived as negative and circles as positive (Watson et al., 2012; Lu et al., 2012; de Rooij, Broekens and Lamers, 2013; Armbruster et al., 2014; Wang and Zhang, 2016) and recent neurophysiological evidence provides further support: "Importantly, ellipse and triangle were found to arouse similar ERP responses to happy and angry faces.., respectively" (Li et al., 2018, p. 7).

I suspect these findings would be of no surprise to visual artists and designers (e.g. see Bang, 2000). Indeed, human-computer interaction and computer scientists de Rooij, Broekens and Lamers regard "abstract art and the developed formalisms by artists an interesting knowledge base from which the role of abstraction in perception and its connection to the construction of experience can be investigated" (2013, p. 4). Their research into "how synthetic affective expressions can be designed with minimal reference to the human body" demonstrates that it's entirely feasible to use "abstraction to create consistent emotional attributions" (de Rooij, Broekens and Lamers, 2013, p. 1). After an extensive review of the literature on "the science behind abstract art and research on affect and emotion attribution to abstractly presented essential affective features" (de Rooij, Broekens and Lamers, 2013, p. 16) the authors go on to outline a design process. They provide "easy lookup" tables of essential features to inform "the design of abstract expressions of affect" (de Rooij, Broekens and Lamers, 2013, p.16)[12].

de Rooij, Broekens and Lamers' table relating to "*Effects of essential affective form features on emotion attribution*" (2013, p. 17, tbl. 2) again reinforces the association of roundness and curvilinearity with positive emotions; angularity and inverted triangles with negative emotions and threat. In addition, the table relates asymmetry with high arousal, and symmetry with low arousal; and size, height, surface area with arousal,

[12] Their pilot study is concerned with robot design, but their process and data are useful for my purposes too.

potency and surprise; non of which contradicts my intuitive choices (see above). Their table concerning "*Effects of essential affective movement features on emotion attributio*n" (2013, p. 17, tbl. 1) shows, amongst other things, perceived instability is attributed to negative emotions, fear and suffering; whereas stability is attributed to positive emotions, joy and surprise (which surprises me!). Smoothness of movement is attributed to pleasure, whereas large, fast, jerky movement is attributed to anger. Although I apply it selectively, this data, and more in their article, is useful to me and influences my emoviz animations.

Animation excels at simulating the physics of motion, but also anthropomorphic effects, imbuing abstract shapes with desires, intentions or emotions (see Goldman, 2013). The minimum requirement seems to be an object whose movement appears to be self-initiated. The effect can be further enhanced with easing equations, which alter the nature and timing of a transition from one state to another, and morphing (changing smoothly) from one shape to another. In the right context, these techniques, applied to shape and/or line, amplified by colour, can suggest an emotional state (e.g. trembling with fear, shaking with anger, breathing with relief) or transitioning from one emotion to another.

Translating data or qualities from one domain to another is fascinating but it presents many challenges. My quest for a more methodical approach led me to build my own digital tool for analysing and testing how different elements of a visualisation react to changing PAD values. This now forms part of my Convowriter. However, the current minimum viable product status of my *Conversengine* (which incorporates the Convowriter) means that my emoviz system is still a work-in-progress and has not yet reached its full expressive potential.

Writing Emotional Data

So, the visualisations in my emoviz system represent the dynamically changing internal state of the fictional characters, their emotions and state of mind, as the reader-player interacts and progresses through the narrative. The emotional source data needs to be formulated and encoded for the moment-by-moment performance of the fictional

character, therefore, it's part of the interactive creative writing process. As I'm writing the text (*lexia*) and metadata that plays within an individual scene (actually, within a course within a scene), I translate the dramatic moments or beats into a quantified emotion for the character. Most lines of dialogue - and for protagonists, some of their own thoughts too - will generate an emotional response in the character/s in the scene. Even if there's no change from line to line, beat to beat, each character is always in some kind of emotional state. So all these moments carry a PAD value. It's a process of quantifying emotion, expressing it as numerical values on the Pleasure Arousal Dominance scales, then translating or projecting that data into a dynamic visualisation.

In this section, I've traced some of the intermedial and intersemiotic permutations of translation back and forth from fictional character, narrative text, numeric data, and code generating dynamic visual forms within the graphical user interface. My hypothesis is that the changing properties of the animated visualisations will work with the onscreen text to conjure up or transmute into fictional characters.

These combined outputs of my narrative system will significantly affect the choices that reader-players make, which are the inputs to the system. This stimulus-response model forms my core gameplay loop. How the reader-player chooses to interpret the characters' behaviour will determine the kind of story they experience and its outcome.

That which is not data...

As both reader and writer, I am interested in characters that are humanlike and have the ability to arouse emotions in the reader. Therefore I need an authoring methodology that facilitates a more humanistic rather than structuralist or formalist approach. I don't want to treat my fictional characters as purely semiotic constructs. In *Eloquent JavaScript*, Haverbeke writes, "Inside the computer's world, there is only data—that which is not data does not exist" (2018, loc. 472). Ergo, since mine is a computer-generated narrative, I must compose humanlike, emotional characters from data, yet the computer demands inhumanly pedantic and unequivocal data. Although I use a human-readable programming language (JavaScript) to write code, the slightest ambiguity, even a missing comma, can render the program unreadable for the computer. This is

antithetical to the creative process where ambiguity is fundamental to the nature of the arts and audience pleasure, which brings me back to my research question. How can a convincing interactive character, with apparent psychological depth and a rich emotional life, be modelled in a playable digital narrative using expressive programming and multimodal languages, including natural language? Clearly, the stuff that is not data, "that which... does not exist" to the computer, is as crucial to my interactive narrative, *Stitched Up*, as the data that it reads, modifies and creates. Managing the relationship between the two is fraught with tension but is necessary to bring interactive characters to 'life'.

Part 2: Developing the *Conversengine*

2.0 The Convowriter

In order to model convincing interactive characters, with apparent psychological depth, in a playable digital narrative that adapts to reader choice, I need an authoring tool that supports a particular set of requirements (described below). With those in mind, I reviewed a number of existing authoring tools but didn't find a suitable one (also discussed below). Therefore, I am building my own platform, the *Conversengine*, for authoring and playing text-driven interactive narratives. However, this thesis focuses only on the authoring tool, the *Convowriter*, which includes the *Playtester*, a dashboard tool for play-testing my interactive narrative, *Stitched Up*. These constitute my minimum viable product (MVP).

Nowadays, in the browser, web designers and developers have tools that give instant visual feedback in the web page (or app view) whenever they make changes in the underlying code. This is such a great boon to web design and development that, for example, when LiveReload[13] (which updates the browser instantly whenever there's a change to an image or CSS without reloading the page) was quietly released one Sunday night in 2010, its developer woke up the next morning and "it seemed like the whole Internet started talking about LiveReload" (Tarantsov, 2011, para. 5). Now cloud computing gives us real-time data updates to and from remote databases that a decade ago would have seemed miraculous. I have been able to reap the benefits of these rapid creative feedback loops when coding, designing and animating but when it came to creative writing for digital storytelling, the process of writing, editing, honing and reviewing the text of my interactive narrative was continually hampered by friction and obstruction.

Prior to developing my own authoring tool, I had tried to work with a combination of writing tools - *Scrivener*, *Aeon Timeline*, *iThoughts* (mind-mapping) and *VS Code*, my code text editor - but it proved too awkward and unwieldy to switch from one tool to another and this impeded my creative flow. A multimodal and multimedia workflow is

[13] http://livereload.com/

necessarily shaped by the tool/s employed (see Koenitz, 2017, p. 2) and it's hard to maintain creative writing flow when there is little responsive feedback and certainly no immediacy in the process. I was forever tweaking my tools to try and make them adapt to my needs but they resisted, and the attempted adaptation or convoluted methodology fell far short of what I needed - an interactive narrative authoring tool that provides a good creative cybernetic feedback loop for my workflow. So I set out to try and find one.

My Requirements of an Authoring Tool

Clearly, an essential criterion was how far the authoring tool in question would reduce friction in my creative flow. Would it enable a fluid oscillation between the different modes of writing, reading and interacting/playing with the onscreen text in the context of the UI and the *emoviz* animations (and iterative variations of both)? This classic feedback loop of the creative process is vital for assessing and refining the whole user experience as well as crafting and writing the interactive storytelling. Due to the nature of my creative project, another essential requirement was that the authoring tool should be able to model dialogue well, whether that be conversation between two (or more) characters or interior dialogue. Thirdly, I needed a writing tool that would support the specific architecture and engineering of the *Conversengine*, my interactive narrative engine with its unique steering-a-course ludonarrative navigational structure (discussed in section 1.6). Finally, the tool should be written in JavaScript to be compatible with my development tool chain or, if not, it should at least output data in a compatible format (e.g. JSON) and with an appropriate data structure suited to my application's needs.

Review of Authoring Tools

I investigated a range of specialist interactive narrative authoring tools. What follows is a brief review of my assessment of these tools, in terms of my requirements, compared with the findings of two other groups of researchers who have undertaken recent surveys of authoring tools.

Shibolet, Knoller and Koenitz (2018) conducted a comprehensive survey and categorisation of interactive digital narrative (IDN) authoring tools, developed in both academic and non-academic contexts (see Knoller and Shibolet, 2018), with a future view to providing a useful online resource for prospective authors. Currently their "database includes a total of 183 tools (146 of which are 'alive')" (Shibolet, Knoller and Koenitz, 2018, p. 526). Their primary level of classification is divided into two groups: "Fully self-contained tools", some of which are relevant for my purposes, and "Partially-generative and non-generative tools", which are not relevant[14] because they "support authoring with externally produced (e.g. recorded) assets" (Shibolet, Knoller and Koenitz, 2018, p. 527). Their "Fully self-contained tools" are further categorised into:

- "*Real-Time Graphical Rendering/Game-Creation Tools*" (e.g. Unity 3D, Unreal)
- "*Hybrid Text + Graphic Tools*" (e.g. Ren'Py, ASAPS)
- "*Interactive Fiction Tools*", which they separate into hypertext tools (e.g. Twine, StorySpace) and parser tools (e.g. Inform 7, VaryTale)

(Shibolet, Knoller and Koenitz, 2018, pp. 526-527)

Since I'm not working with 3D graphics nor creating parser-based interactive fiction, the most interesting of these categories for my research are the *Hybrid Text + Graphic Tools* and the hypertext *Interactive Fiction Tools*.

[14] I also disregarded tools that are no longer 'alive'.

More similar in scope and purpose to my survey[15] is that of Green, Hargood and Charles (2018), who conducted theirs in preparation for building a new "authoring framework for interactive storytelling", *Novella,* which is currently "sporadically in development" (Green, 2019). They focussed specifically on "authoring tools for structural and choice-based narratives" and "broadly categorized [them] by their delivery methods (**Standalone**, **Web-based**, **Integrated**) and high-level interface design paradigms (**Form**, **Graph**, or **Text-based**)" and grouped them as academic, commercial or "other" (Green, Hargood and Charles, 2018, p. 502). The range of tools they evaluated is not completely identical to mine (e.g. they considered more tools from academia, whilst I looked at a greater number of commercial offerings) but there is a significant overlap. Also, our objectives differ in some key respects. Green is setting out to make a tool for macOS, whilst I'm building a cross-platform, web-based tool. He intends his tool for the general authoring public, whereas, in the first instance, I'm building a tool for my own use, although I intend to make it available to other authors in the future. This is an important distinction and a tried and tested strategy in software development, which I will return to below.

Table 5, below, presents a list of the tools assessed and how the respective researchers (Knoller and Shibolet, 2018; Green, Hargood and Charles, 2018), including myself, categorise them.

[15] I only include authoring tools that were available and current before I began developing my own tool in late 2017.

Authoring Tool	Green et al	Knoller & Shibolet	Wilks
articy:draft3	standalone, commercial	Writing aid tools (Interactive tools for linear writing and film)	dialogue modelling (commercial)
ASAPS	standalone, academic	Hybrid text + graphic tools; Academic tools	graphics-based with text
Celtx (formerly Gem)	...	Interactive Fiction tools - Hypertext	dialogue modelling (commercial)
Chatmapper	...	Genre-specific game makers	dialogue modelling (commercial)
ChoiceScript	...	Interactive Fiction tools - Hypertext	of game company origin
HypeDyn	academic	Interactive Fiction tools - Parser; Academic tools	hypertext
ink	...	Interactive Fiction tools - Hypertext	of game company origin
inkleWriter	web-based, graph-based	Interactive Fiction tools - Hypertext	of game company origin
Ren'Py	standalone	Hybrid text + graphic tools - Visual novel authoring tools	graphics-based with text
Scrivener	...	Writing aid tools (Interactive tools for linear writing and film)	linear writing
StoryNexus	...	Interactive Fiction tools - Parser	of game company origin
StoryPlaces	web-based, academic	AR\MR tools; Academic tools	locative literature
Storyspace	standalone, commercial	Interactive Fiction tools - Hypertext; Historical Tools - IF	hypertext (commercial)
TextureWriter	standalone	Interactive Fiction tools - Parser/Hypertext	hypertext
Twine	standalone, web-based, graph-based	Interactive Fiction tools - Hypertext	hypertext
Undum	...	Interactive Fiction tools - Dead	hypertext

Table 5

Here is my assessment of the tools apropos of my requirements, grouped according to my categorisations.

Tools with dialogue modelling features

Three authoring tools stood out in terms of their ability to model dialogue.

articy:draft3 is an interactive storytelling and game content management system, which integrates with the *Unity* and *Unreal* game engines. Although it supports game *writing*, I agree with Knoller and Shibolet that it's "best tailored for large games" (2018, p. 353) and incorporates a lot of unnecessary and distracting features for my project (see figure 25 and my discussion of *Chatmapper* below).

Celtx (formerly ***Celtx Gem***), "The all-in-one solution for film, video, and game production" (Celtx Inc., 2020a) now offers a new, Cloud-based, online, game and VR editor with a facility for interactive choice-based dialogue, which looks promising. But when I started building my own authoring tool, the company was only offering a trial version, named *Celtx Gem* (Celtx, 2018). At that time, it seemed "More of a tool for game devs to collaborate... than an independa[n]t authoring tool" (Knoller and Shibolet, 2018, p. 137).

Chatmapper was one of the first dedicated authoring tools I attempted to use. It provides a decent visual editor for writing branching dialogue which, in Knoller and Shibolet's view, can "theoretically be employed to create a dialogue-based IDN from start to finish" (2018, p. 59). I do not dispute that but, for my project, I felt encumbered (both in the UI/UX and the data output) by unnecessary features that the editor presents and manages (e.g. avatar icons, game assets), which got in the way of my writing/reading oscillating flow. This criticism is also true of *articy:draft* (see figures 24 & 25).

[Image redacted in this digitized version due to potential copyright issues]

Figure 24. *Chatmapper*

[Image redacted in this digitized version due to potential copyright issues]

Figure 25. *articy:draft*

All three tools allow the author to export their script/written data in one data format or another (e.g. XML, JSON or Microsoft Excel) and then integrate it "into your team's

development toolchain" (Celtx Inc., 2020b). But this inevitably involves some form of data processing to make the data structure meet the specific requirements of one's own application and, for my use case, the tools export a lot of redundant data. This extra data processing significantly impedes a fluid, back and forth, iterative workflow. Furthermore, on Mac OS, I would have to use a Windows OS emulator to use either *articy:draft3* or *Chatmapper*, another barrier. For these reasons, I rejected all three tools.

Graphics-based with text & locative literature tools

ASAPS, which stands for “The Advanced Stories Authoring and Presentation System" (Koenitz, no date), is an interesting academic tool "used by Koenitz in classes" (Knoller and Shibolet, 2018, P. 94). However, besides still being in private Beta, it's heavily focused on graphic illustrations, which is not the aesthetic I am pursuing for my project.

The same is true of ***Ren'Py***, a popular "visual novel engine" (Ren’Py, 2019), which, according to Knoller and Shibolet, "seems to be used mostly for manga-style aesthetics and narrative fomulas" (2018, p. 85).

Another tool that I ruled out due to a mismatch in terms of genre, is ***Storyplaces***, used for creating "locative literature", a form which has its roots in digital tour guides but has expanded to include locative interactive fiction (Millard et al., 2017).

Hypertext tools

"***HypeDyn*** is an authoring tool for creating procedural hypertext fiction[16]. HypeDyn focuses on visualizing the content and structure of the story, and providing accessible tools for non-technical authors to create rules and behaviours" (Mitchell, 2014). Another interesting academic tool but, in common with many other tools discussed here, since it prioritises ease of use for non-technical authors, it's not flexible enough for my purposes.

[16] Classified as a parser tool by Knoller and Shibolet (2018, p.4).

Storyspace, a hypertext tool by Eastgate Systems, is "past its prime" according to Knoller and Shibolet (2018, p. 148) and, as it's unavailable for Mac OS X (which first came out in 2001), I rejected it as too outdated for my toolchain.

Knoller and Shibolet describe ***TextureWriter*** (aka ***Texture***) as an "Intuitive, beginner-friendly hypertext tool" (2018, p. 178), although they classify it as a parser tool. The creators were interested in "the possibility space between Inform and Twine" (Leinonen and Munroe, no date) and, in my opinion, the writing and playing experience is more like *Twine* with a drag and drop mechanic. However the tool is too limited for my purposes.

Twine, originally created by Chris Klimas in 2009 (Interactive Fiction Technology Foundation, no date), is regarded by Knoller and Shibolet as "The most alive and kicking hypertext tool and community... very interesting, highly expandable, and has been used for some great products" (2018, p. 153). I have a great fondness for this tool but it does not meet my requirements. Although *Twine* is very flexible, I find that, like many other hypertext tools, it's more suited to interactive narratives that rely on narration and which present blocks of dialogue on the web page in a prose-style form of presentation; whereas I want to animate the flow of conversation and interior dialogue in a more time-based, dramaturgically performative fashion. I decided it would be too difficult to customise it to fully meet my needs.

Undum is "a highly mutable code-based IF tool for creators with Javascript and HTML knowledge" (Knoller and Shibolet, 2018, p. 187). Although classified as "Dead" by Knoller and Shibolet (2018, p. 5), which is true of its public website, the JavaScript code (library) is still available on Github (Dias, 2015) so I considered using it. However, the particular interactive narrative architecture that it supports wasn't suitable for my project.

Tools originated by game companies

These are authoring tools created by independent game companies, initially, to meet their own custom game platform and choice-based interactive storytelling requirements. Subsequently, they offered their tools and/or platforms to the public, some with their

own custom scripting markup languages[17].

StoryNexus is the software Failbetter Games used to create their interactive narrative, *Fallen London.* They turned it "into an open, though moderated, browser-based authoring tool... [and] publishing environment... for highly gamified hypertext" (Knoller and Shibolet, 2018, p. 175). However, in 2013, they put *StoryNexus* into maintenance mode, "disabled the creation of new worlds in January 2019" and now plan "to retire all user-created StoryNexus worlds" (Flynn, 2020, para. 2). It was not suitable for my project.

Game company, Choice of Games, encourage authors to use ***ChoiceScript***, their "simple programming language for writing multiple-choice games" (Choice of Games LLC, 2010, para. 2) to create their particular style of "'choose a path' gamebooks... [which] are written according to a distinctive set of game design principles" (Choice of Games LLC, 2011, para. 1). As Knoller and Shibolet acknowledge, it's "Quite successful in it[s] own community" (2018, p. 134) but it's too prescriptive for my needs.

Independent narrative game company, inkle, offer two open-source tools, *inklewriter* and *ink*. "***inklewriter*** is an easy-to-use online tool to write basic interactive stories" (Inkle Ltd, no date-b, para. 15). Released in 2012, they struggled to maintain it and it was "in shutdown mode" for over a year until its relaunch in March 2019, thanks to a team of open-source developers (Inkle Ltd, 2019a, para. 4). Knoller and Shibolet regard it a "promising hypertext tool" (2018, p. 139) but, as Inkle themselves say, it's more of "a quick sketch-pad, for bashing out ideas" (2019b, para. 17) so it's not appropriate for my use case.

"***ink*** by comparison is a more powerful narrative scripting language that is primarily designed for professional game development, though it can also be used to write and share choice-based interactive fiction" (Inkle Ltd, no date-a, para. 21). It also offers Unity integration. Inkle have used it for all their critically acclaimed narrative games.

[17] "a markup language is a system for annotating a document in a way that is syntactically distinguishable from the text... Markup instructs the software that displays the text to carry out appropriate actions, but is omitted from the version of the text that users see" (Science Europe Data Glossary, 2015).

Consequently, *ink* is tailored to their specific narrative design needs - with concepts such as "knots", "stitches" and "diverts", etc. (Inkle Ltd, no date-c) - so it wasn't a good fit for my project.

The Convowriter Authoring Tool Features

Stitched Up branches, not only between three notional narrative courses, but also at the granular level of dialogue (and interior monologue), and includes beat-by-beat emotional visual responses. Because of the intricate complexity of what I'm creating, the authoring tools I reviewed above were either too limited for my purposes, inappropriate for my project, or primarily designed for writing then handoff to a programming team working in some other platform (e.g. Unity), which would hardly facilitate a free-flowing creative feedback loop. Therefore, I decided to build my own tool.

Building tools to meet your own needs with the conscious intention that others may find them useful is a common strategy in software development and a key principle of the IndieWeb, "a people-focused alternative to the 'corporate web'" (IndieWeb, 2019a, para. 1). It's known as "scratch your own itch" and it urges developers to make tools for themselves first rather than "some hypothetical user, [who] may not actually exist" (IndieWeb, 2019b, para. 3). In this way you know you're fulfilling a real need rather than a speculative one and, if you "make what you need" and, crucially, "use what you make" (i.e. keep developing the tool, keep it current), others may benefit in the future (IndieWeb, 2019b, para. 5). Indeed, some of the well-known tools discussed above began in this way (e.g. ChoiceScript, ink & inkleWriter, Scrivener[18], StoryNexus, TextureWriter, Twine).

The *Convowriter* is the integrated authoring tool of my *Conversengine* platform and is designed to support its unique *steering-a-course* ludonarrative engine and database architecture. The parts, governing story data input and story data display, work seamlessly together. Every edit or new piece of text entered in the writing tool

[18] Scrivener is made by "Literature & Latte, a software company founded by writers for writers" (https://www.literatureandlatte.com/about-us).

immediately updates the database in the Cloud and the changes are instantly reflected in all areas of the user interface, the writing tool and the *Playtester*. This enables a responsive and fluid iterative workflow for creative *interactive* writing - by which I mean, both writing the interactive narrative, and also the process of interacting with the narrative material (text and visuals) to design and craft the whole dynamic, multimodal, digital, ludonarrative experience.

The tool is designed for writing dialogue (including interior dialogue), and so it's optimised for short lexia rather than long blocks of text. Unlike other tools for writing branching dialogue (see figures 24 & 25), it foregrounds the words, clearly showing which lines belong to which character without taking up too much screen 'real estate' or cluttering up the UI. This style of presentation, influenced by drama script formats, provides a better writing-reading flow with minimal visual disturbances, which is especially important when dramatic dialogue is the primary storytelling mode. Complex characters are created through a writerly process, therefore it's vital to have a writing tool that facilitates rather than impedes the interactive writing process.

Since the *Conversengine* animates the flow of conversation and interior dialogue in a time-based performative fashion, the writer needs to be able to quickly see how the written words perform in terms of visual rhythm, prosody, legibility and timing. In other words, seeing how a specific sequence of words looks or animates within a dynamic visual context can lead to edits in the writing. It's therefore crucial to be able to move back and forth quickly between different modes of working with the text.

An original feature of the *Conversengine* is its *emoviz* emotional data visualisation system (see sections 1.7 & 1.8). Combined with the characters' textual speech and thoughts, the *emoviz* system presents a new way of materialising complex interactive characters with psychological and emotional depth. The *Convowriter*, therefore, provides the means to write and edit the PAD (Pleasure, Arousal and Dominance) data that drives the characters' emotional responses. It also provides of way of reviewing and testing how the emotional data visualisations work in practice in the scene *Playtester* feature, and the built-in *PAD emoviz* tool allows the writer to isolate and test the visualisation of specific PAD values. Naturally, these features are unique to my authoring tool.

Another major advantage of building my own tool is that I can display the story data in any number of ways to suit the writer's needs. By selecting, filtering and arranging it using different criteria, and by applying different CSS designs, the same story data can be presented in countless varied ways. I will be adding more alternatives in the future but, already, even in its current minimal viable product (MVP) form, the *Convowriter* offers numerous ways to read, review and edit the text. For example, you can choose to focus on a single course within a scene or view all three courses - *Under-par (UN), Optimum (OP), Overkill (VK*) - side by side. Or you can choose to orientate the course view with a focus on the actor or a focus on the current tack (i.e. course within a course), or view both together. Being able to read and compare the narrative courses, and also the courses within a scene, side by side - to assess the flow, to see commonalities and differences, and to see where the dramatic turning points are - is essential for keeping a check on narrative consistency. Since the reader-player is able to steer their own course through the narrative, if something happens in one particular course, which could have ramifications further down the line in subsequent scenes, then I need to make sure that, if the reader-player switches course, that narrative coherence remains intact.

In short, the *Convowriter* authoring tool gives the writer responsive timely feedback and allows them to survey and monitor the overall structure of a course or scene, how it relates to other courses and scenes, and the interactive narrative structure as a whole.

Having looked at the creative issues the *Convowriter* solves on a practical level, I'll now discuss these issues from a theoretical perspective because, as theory informs practice (see Methodology section), the narratological distinction between story and discourse (or *fabula* and *sujet*) has informed its design just as much as the specification of functional requirements.

2.1 Story and Discourse

> [N]arrative is the representation of events, consisting of story and narrative discourse; story is an event or sequence of events (the action); and narrative discourse is those events as represented.
> (Abbott, 2008, p. 19)

When the reader-player interacts with *Stitched Up* they experience the narrative discourse - i.e. the dynamic story events as reordered through narrative discourse (see Kukkonen, 2014, para. 22). The multimodal discourse of *Stitched Up* relies upon a graphical user interface (GUI) that drip feeds narrative information, one line of dialogue (or character's thought) at a time, at a comfortable reading pace in a visually and temporally expressive way. As Ian McEwan said, “Narrative tension is primarily about withholding information” (quoted in Zalewski, 2009, para. 7) and the same is true of interactive narrative. *Stitched Up*'s GUI and its underlying operational logics are designed with the express purpose of withholding information from the reader-player as they interact with it - another instance of a black box. But the writer of an interactive narrative needs easy access to all the narrative information, to both story and discourse, whenever and however it suits them and their creative process. They need to work inside the black box because, recalling Glanville (2009), the writer is an active participant in forming and operating the black box.

As the writer, I am also the first reader-player of my narrative but, as the writer-artist-programmer working on the narrative, I need a different kind of user interface. I need to be able to see what the reader-player will see but, equally, I need all the multimodal narrative information at my fingertips - accessible, scannable and easily understandable. As the writer-maker-coder, I have to create and manage the story (*fabula*), the sequence of "events in the actual temporal and causal order" (Kukkonen, 2014, para. 22), as well as the discourse (*sujet*). Since *Stitched Up* is an interactive narrative, where the reader-player steers their own course through the diegesis, the creation and revising of story and discourse is more complicated than in a non-interactive linear narrative. I need to be able to conceptually hold, manage and manipulate all the narrative material, with its multiplicity of possibilities, in order to work out how best to drip feed the dynamic discourse to the reader-player. I need to be able to pass easily between inside and

outside the black box.

Discussing authorial expression in digital media works, Wardrip-Fruin says, “Rather than defining the sequence of words for a book or images for a film, today’s authors are increasingly defining the rules for system behaviour” (2009, p. 3). But these underlying algorithms are rarely, if ever, made explicit to the audience, they are inside the black box. Instead, “the surface of a work of digital media is what the audience experiences: the output of the processes operating on the data, in the context of the physical hardware and setting, through which any audience interaction takes place” (2009, p. 10). Taking the digital media work as the text in the semiotic sense (as a sign system), French theorist, Bootz, refers to this surface output as the "*texte-à-voir"*, meaning the text-to-be-seen or text-of-visualisation (2005, para. 14). From the reader's point of view, this constitutes "the text" because the program and data, which Bootz calls the "*texte-auteur"* (2005, para. 14), is inaccessible to them. That is the author's domain. So, with regard to interactive narrative, the surface or *texte-à-voir* can be equated with narrative discourse (*sujet*) and the data are part of the story (*fabula*). The program's black-box algorithms process the data to produce the surface discourse. Or, to put it another way, the *texte-auteur*, which includes the story data, produces the *texte-à-voir*, which is the discourse.

Wardrip-Fruin goes on to stress how important it is "to think about the *relationship* between system processes and audience experiences" (2009, p. 15) and identifies three effects that can arise:

The Eliza Effect - "the well-known phenomenon in which audience expectations allow a digital media system to appear much more complex on its surface than is supported by its underlying structure” (Wardrip-Fruin, 2009, p. 15).

The Tale-Spin Effect - occurs in "works that fail to represent their internal system richness on their surfaces" (Wardrip-Fruin, 2009, p. 16).

The SimCity effect - "systems that shape their surface experience to enable the audience to build up an understanding of their internal structure, especially a relatively complex one” (Wardrip-Fruin, 2009, p. 16).

My aim for my interactive narrative system, and *Stitched Up* specifically, is to take advantage of the 'Eliza effect' where it suffices, to avoid the 'Tale-Spin effect', and to reproduce the 'SimCity effect' wherever I can. This is an ambitious and complex undertaking and I need a suitable authoring tool. I need an expressive writing system that reveals the underlying complexity and expressiveness of what I'm creating as I'm writing. Without such a tool, it's hard to write fluently at the necessary granular interactive level and, perhaps more importantly, it's difficult to create a complex interactive narrative processing system that does not hide its complexity and, therefore, its expressivity from the reader-player. If it's hidden from the writer-maker, it's sure to be hidden from the reader-player.

Koenitz asks "What Drives the Creation of Authoring Tools?" and writes, "It seems intuitively clear that any given authoring tool shapes the creative process and thus influences the resulting products in both direct and indirect ways" (2017, p. 2). For Koenitz, the question remains open and research is ongoing (see Shibolet, Knoller and Koenitz, 2018) but this has certainly been my experience and is what drove me to create an interactive narrative platform of my own. This entails developing my own domain-specific language (DSL) that is "understandable not only to the hardware underneath, but also to a curious human mind" (Ghosh, 2016, p. 14). In the next section, I discuss how my custom-built authoring tool and domain-specific language help me craft and negotiate the relationship between code, natural language and storytelling techniques (e.g. by modelling characters as digital actors) and thus enable a more fluent creative writing process. At present, I am developing the *Conversengine* to meet my own creative needs[19] but I hope, in future, it will have potential for other digital authors too.

[19] "Make what you need" is a key principle of the indie web community - https://indieweb.org/principles

2.2 A Room = A Platform of One's Own

The world of game development is heavily male dominated and sexism is notoriously endemic in online gaming and videogames (see Liss-Schultz, 2014). In this context, as a feminist woman and sole writer, developer and designer of an interactive digital narrative, I am something of a rarity. Doing it all myself may seem perverse, especially in a field where collaboration is common, but the ability to author code myself is empowering and, crucially, gives me independence - a platform of one's own - archetypal feminist goals.

Famously, Virginia Woolf argued that a woman writer must have "a room of her own if she is to write fiction" (1929, p. 21). As a woman digital writer, artist and developer/coder living in the 21st century, the computer and the internet also constitute my space to work and publish. So, from my perspective, if I am to write and make interactive digital fiction, I feel the need for a development environment and publishing platform of my own. The connection between Woolf's classic feminist text and programming has not gone unnoticed. For example, see *A Computer of One's Own: Pioneers of the Computing Age* (Videla and Grattarola, 2018), a series of articles about women innovators, starting with Ada Lovelace. Despite the dominance of the social media giants, the internet is still a good medium for independent producers. Here again, I'm inspired by Woolf's example. Literary scholars have noted that when she left the press that had published her first two novels, it "'liberated [her] experimentalism.' Having her own publishing house, the Hogarth Press, meant that she was 'able to do what' she 'like[d]--no editors, or publishers, and only people to read who more or less like that sort of thing' (Letters, 167)" (Zunshine, 2006, quoting Woolf, loc. 753).

The usual advice, especially for independent game and interactive digital narrative (IDN) developers, is don't reinvent the wheel, find an existing game engine and use it to build your own unique game or IDN. In many cases, this is sound advice, and I spent some time researching existing game engines and frameworks, but I didn't find anything that would meet the needs of my vision for this particular creative project without compromising it too much. From past experience of working on *Inkubus* (Campbell and Wilks, 2014), a 3D digital narrative made in collaboration with Andy

Campbell, I was aware of how using existing game engine software can subtly (or not so subtly) coerce you into working and thinking creatively in a particular way. Many artists, and Campbell is an excellent example, thrive on such constraints and creatively repurpose tools to produce brilliantly inventive and original work. Sometimes this works for me too but in this instance, for *Stitched Up*, I felt it would be counterproductive to work against the grain of the dominant videogame conventions that existing tools are designed to facilitate. Let me illustrate with an example.

Consider the choice of virtual camera viewpoint in 3D game engines. As the documentation for the Unity software states, "Cameras are the devices that capture and display the world to the player. By customizing and manipulating cameras, you can make the presentation of your game truly unique" (Unity Technologies, 2015, para. 1). *Inkubus*, which uses a subjective camera for the player to explore the storyworld, was created in Unity but we began development in CopperCube, another 3D game engine. In the CopperCube documentation, the subjective virtual camera is actually called a "First Person Shooter Camera" or "FPS camera", whereas the objective camera is simply called "Third Person Camera" (Ambiera e.U., no date, para. 4). The Unity documentation does not explicitly name this camera perspective however this is their only use-case example: "For a first-person shooter, you would parent the Camera to the player character, and place it at the character's eye level" (Unity Technologies, 2015, para. 7), which suggests that is, in fact, its main purpose. 3D games borrow much from cinema including the male-gendered gaze of the camera (see Mulvey, 1975), which is even more overwhelming in First-Person Shooters since the player characters are predominantly male.

Campbell and I were both keen to subvert the stereotypical use of the game engine but I was struck by the irony of our endeavour: "*Inkubus* is trying to challenge female gender stereotypes and we're creating it, partly, with a tool that embodies male gender stereotypes" (Wilks, 2013). Collaborating with Campbell was a rewarding experience, but I found working with 3D game engines frustrating:

> I think it's very significant that the first person camera has been appropriated by the games industry as an aggressive p.o.v., often literally looking down the barrel of a gun… we are creatively repurposing these features of the software,

> subverting them, pushing them to another place. But we can't deny that there are limitations to the software and these affect how we can tell our story.
> (Wilks, 2013)

Dubberly and Pangaro are designers, theorists and teachers who regard cybernetics as "a science for design" (Pangaro, 2014, p. 4). They assert that "A software program interacts with its 'users,' serving them and yet also constraining their behavior. Software, too, only makes sense when framed as part of larger systems that include humans. These larger systems are what interaction designers design" (Dubberly & Pangaro, 2015, para. 70). The game development community is overwhelmingly male (Weststar & Legault, 2015, p. 4) and this gender bias is reflected in the design of the tools, the language of the documentation and many of the games. It is hardly surprising then that most game development environments do not feel like a room of my own for my creative work, indeed, in subtle ways, I feel locked out of those rooms. I feel much less friction when working with open source web technologies (HTML, CSS and JavaScript). Even though web development is still a male-dominated field (Dodds, no date), the programming languages and software are more generic, more gender-neutral. So those are the tools I prefer to custom build a development environment of my own.

Game designer and developer of interactive storytelling software, Chris Crawford defines interactivity as "A cyclic process between two or more active agents in which each agent alternately listens, thinks, and speaks. That describes a conversation, and interactions with a computer should aspire to be like conversations" (2012, p.245).

In any dialogue, the language you have at your disposal to express your ideas is of vital importance. *Stitched Up* is a text-driven interactive narrative with original game mechanics and a responsive abstract graphical user interface, which means that a subjective point-of-view, rather than being associated with a First-Person Shooter camera, becomes more aligned with the literary first-person perspective. All these combined features, coupled with the nature of the story, make *Stitched Up* a highly unusual interactive creative work, which requires a new way of thinking, a new interactive vocabulary, a new domain-specific language for these kinds of works.

Finding the Language

Verbs: what can the player do?

Crawford asserts that “Interactivity requires verb thinking” (2012, p.86). In the case of interactive storytelling, he argues that “The most important component of storyworld is the verb, which forms the core of an event” (Crawford 2012, p.159). Many leading game designers and writers from the games industry think likewise. Here are some examples from the *Critical Path* archive of video interviews.

Matthew Weise, who runs film-to-game workshops with his wife (she remains nameless in the interview), says they think about “verbs as a way to understand mechanics” (Weise, 2015). The crucial decision is what mechanics you choose and in what combination: “So shoot and jump is one game, shoot and apologise is a really different game, and one of those games is actually dramatically engaged with what shooting means and the other game is, you know, some kind of a Rambo game” (Weise, 2015). Jill Murray, scriptwriter for *Assassin’s Creed IV*, discusses how “game design controls all the verbs” and says, “the mechanics that you have and the fundamental verbs that you have, even before you start level designing, shape what you’re able to say and how you’re able to say it” (Murray, 2014).

I don’t want to be stuck with other game developers’ (patriarchal) verbs, trying to tell my story with a language designed for other, incompatible purposes. To be fully expressive as a creative artist, I need to be able to use my own language or make an existing language my own.

In another video interview, Creative Director Clint Hocking sees similarities between the way the language of cinema evolved and the way the language of game design is evolving and becoming formalised. While audiences benefit from this stabilisation of language because they can better understand it, he worries that “we do risk limiting - dramatically limiting - the kinds of ways we can express ourselves in games” (Hocking, 2016).

All the game frameworks and engines I researched were built to cater, almost exclusively, for game design based on the formalised language and mechanics, largely determined by mainstream or popular gaming. Experimentation still happens but the game-makers' and interactive storytellers' dedicated tools for the job are designed to meet the needs of the majority of users, or the biggest market segment, or the biggest commercial 'players' in the business. I don't want to shoehorn my story or creative vision to fit someone else's limiting vocabulary. A different kind of narrative game with different expressive needs, requires different game mechanics. If I want to tell an interactive story that is more to do with emotional relationships than action and adventure, I need to use different language, different metaphors and a different set of verbs (more on this section 2.4). I have found the best way of achieving this is to build my own authoring tool.

Verb thinking, cybernetics and possible worlds

Instead of features commonly found in game engines, such as physics engines and complex skeletal and facial animation systems, my interactive narrative is driven by a custom-built engine designed upon some key principles from cybernetics mapped to Possible Worlds theory. This gives me an underlying system that can support a more appropriate range of verbs, which, as Crawford says, are the most important components of storyworlds because the verb "forms the core of an event" (2012, 159).

This applies at the code level too. When I started work on *Stitched Up*, I planned to use an Object Oriented Programming (OOP)[20] style but that paradigm encourages thinking in terms of objects - game objects, characters as objects. This works for most video games because they're concerned with external action which is all about manipulating objects in the game world (Alvarado et al., 2013, no longer available), but as my research and my project developed, I realised it wasn't the best approach for *Stitched Up*.

[20] OOP uses data structures that are objects which encapsulate both data and functions (behaviour).

I now favour a more Functional Reactive Programming (FRP)[21] style (although I still use OOP) because it offers a better model for responding to events, particularly streams of asynchronous events. ‘Everything is a stream’ is a mantra of Reactive Programming (Medeiros, 2014, para. 36). A stream of events can be anything - user clicks, a Twitter feed, a video stream, weather forecasts, data structures, animation, a stream of words. My text-based interactive narrative is about emotionally responsive characters and uses dialogue, internal monologue and emotional data visualisations. I find it productive to think of these features, and therefore to program them, as streams of (asynchronous) events. This seems fitting because, after all, literary theory gives us the notion of ‘stream of consciousness’. The Reactive Programming style also suits my structural and navigational design - the art of steering a course through the narrative is also a stream on a macro level.

So, here again is another example of how programming concepts and the language of programming can influence the way you think creatively - it can either help or hinder how you express your idea or vision (story). Most game engines are based on Object Oriented Programming, it's "the secret sauce in 3D graphics and video games" (Alvarado et al., 2013, no longer available), and I wonder, is it more than coincidence that so many video games objectify the female body? I would never argue that using Reactive Programming in some way magically guards against objectification but I've found that it facilitates different ways of thinking about interactivity, different ways of verb thinking, which are more suited to my artistic and narrative concerns.

I find that programming with streams[22] provides an emotionally richer vocabulary of game verbs, which is why, perverse as it may seem, I'm doing everything myself. I need to experience these aspects of code first hand in order to discover what the creative possibilities are. In this way, rather than having to shoehorn my ideas into a predetermined set of inadequate verbs, I can express my dynamic story using my own language - I can find my own voice.

[21] FRP is programming with asynchronous data streams and focuses, not on objects but rather, on functions reacting to events.
[22] In programming languages such as JavaScript, manipulating streams of events or data is known as programming with Observables.

Nouns: the problem of naming things

> Whereas the object-oriented approach tends to break problems into groupings of "nouns," or objects, a functional approach breaks the same problem into groupings of "verbs," or functions.
> (Fogus 2013, p. 6)

Just as nouns and verbs are essential to any natural language, objects and functions are integral to any programming language, no matter what style you prefer. "Typical adult English speakers have some 20,000 words in their vocabulary. Few programming languages come with 20,000 commands built in" (Haverbeke, 2018, p. 39). Therefore, when writing code, you have to define new vocabulary. You have to create your own values, objects and functions to represent and do specific things in your program, and you must name them to invoke them and their names must be unique within the scope of your code.

> Names are everywhere in software. We name our variables, our functions, our arguments, classes, and packages. We name our source files and the directories that contain them... We name and name and name. Because we do so much of it, we'd better do it well.
> (Ottinger, 2008, loc. 795)

It's not as easy as it sounds. Programmers spend more time reading code (including their own) than writing it, so choosing the wrong name could confuse or mislead the human reader, the programmer. A good name for a parcel of code "should answer all the big questions. It should tell you why it exists, what it does, and how it is used" (Ottinger, 2008, loc. 801).

The problem of naming things is not unique to code. For example, without the right name, novelist Ursula Le Guin can't conjure up (invoke) her fictional characters:

> ...before I know much of anything about the story: I have to see the place, the landscape; and I have to know the principle people. **By name**. And it has to be **the right name**. If it's the wrong name, the character won't come to me. I won't know who they are. I won't be able to be them. They won't talk. **They won't *do***

> **anything**. Please don't ask me how I arrive at the name and how I know when it's the right name; I have no idea. When I hear it, I know it. **And I know where the person is**. And then the story can begin.
> (Le Guin, 2004, pp. 278-279) [my emphasis]

Note the similarity to the way names operate in computer software. A chunk of code is stored and *located* in computer memory using its name as a reference. Invoking the name (in another part of the code) makes the block of code that it refers to *do* something (e.g. *calling* a function by name executes the block of code it encapsulates at runtime).

Also, from the perspective of the reader of fiction, names are essential. "Reduced to the very minimum, a character is simply a collection of the words that relate to a particular proper name occurring at intervals within the long series of words that makes up a narrative" (Palmer, 2004, loc. 193). The name is key, it invokes the fictional character in the mind of the reader, without it, they would likely lose track or grasp of the character (*Deception*, a novel without character names by Philip Roth, is a rare exception and, to some extent, it proves the rule). The power of the name applies to other narrative entities too. For example, in fantasy or science-fiction, "Simply naming a planet, ancient war or obscure technical detail seems to trigger the neural process of building it, as if it actually exists" (Storr, 2019, p. 31).

Novelist and programmer Vikram Chandra acknowledges that "Both writers and programmers struggle with language" (2013, loc. 126) and I'm no exception. I've spent a good deal of time and thought on naming the entities in both my narrative and my code (more on this section 2.4). Writers and programmers also struggle with structure but software developers have the additional challenge of managing changing state. As Chandra says, "Software is complicated because it tries to model the irreducible complexity of the world" (2013, loc. 1954). Programmers and software engineers have developed various methodologies to meet this challenge. One such is *domain-driven design* (DDD), which I have found particularly helpful.

2.3 Defining my Domain

Avoiding a big ball of mud with domain-driven design

> Questions about whether design is necessary or affordable are quite beside the point: design is inevitable. The alternative to good design is bad design, not no design at all.
> (Vernon 2016, loc. 263, quoting Douglas Martin)

As the sole creator of my interactive narrative, *Stitched Up*, I'm responsible for its content and all aspects of its design - its look and feel, and how it works. Regarding the latter, Vaughn Vernon, a leading proponent of domain-driven design (DDD), stresses the importance of spending enough time and thought on the design of software before diving into code. He says that too often he comes across software development teams that fall for the "No Design" fallacy (Vernon, 2016, loc. 263) and their software architecture inevitably turns into a *Big Ball of Mud* (Foote & Yoder, 1999) - an haphazardly-structured monolithic system that "has multiple tangled models without explicit boundaries" (Vernon 2016, loc. 385). Domain-driven design aims to avoid this problem[23] by employing a "strategic design pattern called *Bounded Contexts*" and, crucially, by inducing programmers and "*Domain Experts"* to collaborate to develop a "*Ubiquitous Language*" which is used pervasively "throughout the team's spoken communication and software model" (Vernon 2016, loc. 299).

> Domain-driven design is not a technology or a methodology. DDD provides a structure of practices and terminology for making design decisions that focus and accelerate software projects dealing with complicated domains.
> (Gitlevich & Evans, 2007, para. 7)

Coming from the world of business software development, domain-driven design has obvious benefits for teams, but I also found this structure of practices beneficial. I may be a sole creator but I take on many roles and the constant context switching can be

[23] In *Clean Code*, Martin gives an example of a company who "wrote a killer app" in the late 80s but "had rushed the product to market and had made a huge mess in the code", which eventually became so unmaintainable that it "brought the company down" (2008, loc. 535 to 539).

draining and confusing, especially when apparently similar concepts and terminology from one domain mean or refer to very different things in another. Take, for example, the terms 'model' or 'abstraction'. I originally trained in the visual arts and those words have particular meaning for an artist. Now that I am also a software developer, I need to use these terms in the context of computing where their meaning is different. But it's not just about using terminology correctly, it's about using those concepts in practice to make complex artefacts. The semantics and concepts from both domains, amongst others, are relevant to my transdisciplinary project and I needed to find ways of mapping them from one context to another. I wanted to reconcile these methodologies and ontologies to avoid becoming mired in a tangle of semantically crossed wires.

"For any application that you develop, the core concept is the *domain model*, which is the representation of how the business works" (Ghosh 2016, p. 1). To pick that apart, I'll start with some definitions from domain-driven design.

A domain is "A sphere of knowledge, influence, or activity. The subject area to which the user applies a program is the domain of the software" (Evans, 2015, p. 6).

Broadly speaking, my domain is creating an interactive digital narrative. Nested within that is the specific domain of *Stitched Up*, a particular instantiation of an interactive narrative with a unique combination of features.

A model is "A system of abstractions that describes selected aspects of a domain and can be used to solve problems related to that domain" (Evans, 2015, p. 6).

The general problem space of my domain is how to effectively translate my fictional characters and their emotional stories into working code to produce a dynamic but coherent interactive narrative. This also involves how to model interactive fictional minds to bring characters to life. The question is which aspects of a domain to select to abstract into a model.

> When you're implementing a domain model, an understanding of the domain is of paramount importance. Only when you grasp how the various entities work in the real world will you have the knowledge to implement them as part of your

> solution. Understanding the domain and abstracting the central characteristics in the form of a model is known as *domain-driven design* (DDD).
> (Ghosh, 2016, pp. 4-5)

When implementing a domain model for a business application, "you translate the business processes into software. You try to make this translation in a way that results in the software resembling the original processes as much as possible" (Ghosh, 2016, p. 2). But in my domain, there are no original real world processes to translate, or if there are, where they originate is not obvious or straightforward. Instead of real people interacting in a real world situation, I have fictional characters interacting in a fictional world (the reader is real but once interacting in the fictional world they are, in effect, playing a character). The processes I need to translate into software derive from a narrative, which is itself a process of storytelling, a process of invention. Since my narrative structure and software architecture are intimately intertwined, it was not obvious, at first, where to begin.

I chose to start with language. After all, as we've already seen, the key question is, "What does the user do?" (Crawford, 2012, p. 91) and therefore "the verbs define the software" (Crawford, 2017, para. 1). Similarly, effective domain-driven design depends on developing the Ubiquitous Language and, significantly, it is the domain expert's "mental model that we start with to form the foundation of the team's *Ubiquitous Language*" (Vernon, 2016, loc. 488). I am one person performing a team of different roles but in my role as creative writer (and artist-designer) of my interactive narrative, I am the domain expert. Therefore, I reasoned, I should begin with my mental model as a creative writer (and artist) to form the foundation of my project's Ubiquitous Language - in other words, storytelling.

Story data and process

Crawford prefers the expression "interactive storytelling" to terms such as "Interactive narrative" because it suggests a more dynamic process (2012, loc. 964):

> …a story is data, not process. You can't interact with data; interaction centers on process. Images, sounds, text, and numbers are all forms of data. You can't interact with any of these. They don't do anything. You can interact with a

> process because it's alive—it's taking place, and you can intervene in that process to change the way it operates, creating an interactive loop with it. A story is data; it's fixed, permanent, and unchanging, so you can't interact with it. But storytelling is a process, a dynamic process that you can intervene in, alter, play with, and thereby interact with.
> (Crawford, 2012, p. 46)

I think he overstates the fixity of story by ignoring the reader's role in the process of reading. For instance, Manovich states:

> In contrast to most games, most narratives do not require algorithm-like behavior from their readers. However, narratives and games are similar in that the user must uncover their underlying logic while proceeding through them - their algorithm. Just like the game player, the reader of a novel gradually reconstructs the algorithm (here I use the term metaphorically) that the writer used to create the settings, the characters, and the events.
> (2001, p. 225)

So, by extension, an interactive digital narrative involves algorithms in both the literal and metaphorical sense - which is partly why I use the term, 'reader-player'.

Despite Crawford's dogmatism, I find his distinction between story as data and storytelling as process useful because the two main features of any software program are behaviour (process) and data. Or as Manovich says, "Together, data structures and algorithms are two halves of the ontology of the world according to a computer" (2001, p. 223). Both encourage me to think about the act of creative writing as a process for producing story data, as distinct from the process of designing and developing the behaviour of my interactive narrative program, the algorithms that will manipulate the story data (often in response to the reader-player's input) to produce a dynamic narrative experience.

For Manovich, a defining characteristic of a "new media object" is that it "*consists of one or more interfaces to a database"* (2001, p. 227). Although he argues that "database and narrative are natural enemies" (2001, p. 225), he concedes that "a database can support narrative" (2001, p. 228). My story data is stored in a database[24] and, as such,

[24] Google's Cloud Firestore NoSQL database -

needs to be structured "for efficient search and retrieval" (Manovich, 2001, p. 223), also known as data querying. The algorithms I write, "the rules that operate in the universe constructed" (Manovich, 2001, p. 222) by my interactive narrative, do the querying, sometimes in response to user input when they make a choice. In such cases the "'user' of narrative is traversing a database, following links between its records as established by the database's creator. An interactive narrative... can then be understood as the sum of multiple trajectories through a database" (Manovich, 2001, p. 227).

As author - in the sense of being the writer, the developer and the designer - I am the database creator as well as multiple types of user. The writer needs a different kind of interface to the reader-player. Indeed, the writer needs several user interfaces because writing also involves reading. The developer needs specialised user interface for handling the data structure and algorithms, and the designer, a user interface for handling the visual aspects. This makes the whole project, The *Conversengine* and *Stitched Up*, highly complex. It's a chicken and egg situation, deciding which comes first, the database or the interfaces, the story data or the algorithms. The truth is, they are utterly interdependent and the entire creation process is iterative, cyclical and time-consuming.

Deliberating and developing my own Ubiquitous Language became essential to bring clarity to my project. This was the key to initiating within myself “a creative collaboration between technical and domain experts to iteratively cut ever closer to the conceptual heart of the problem” (Gitlevich & Evans, 2007, para. 5).

2.4 Developing my Domain-Specific Language

To facilitate creative collaboration when exploring complex business domains, Brandolini, a domain-driven design specialist, has evolved a fast-paced workshop-style learning process which he calls 'Event Storming' (2013). This gathers an interdisciplinary team in a room with a long paper roll, marker pens and lots of coloured sticky notes to “start modelling problems that looked too big to be modelled”

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https://firebase.google.com/products/firestore/

(Brandolini, 2015, para. 3). Since for my project, there is only me, I adapted Event Storming into a virtual format using, Scapple, a free-form note-taking and mind-mapping tool (Literature and Latte Ltd., 2017).

As Vernon advises, “If you follow the direction of your *Ubiquitous Language*, you will generally create the proper abstractions. It’s much easier to model the abstractions correctly because it is the *Domain Experts* who convey at least the genesis of your modeling language” (Vernon 2016, loc. 1235).

As my own domain expert, I arrived at a Ubiquitous Language to help model the proper abstractions for both authoring and playing my interactive narrative. Below, I highlight some of the considerations that went into naming certain aspects of my *Conversengine* domain-specific language[25].

Features of the *Conversengine*

Conversengine - the whole authoring and publishing platform: 'converse' captures the idea of a conversation and also the sense of opposite, antithesis and conflict; 'engine' because it incorporates a mechanism for driving an interactive narrative.

Convoplayer - a planned feature where future reader-players will be able to play published IDNs. The name derives from *Conversengine* and incorporates notions of playing a game, playing an animation and playing a character or dramatic part.

Convowriter - manifestly, the interactive digital narrative authoring tool.

Playtester - an area of the Convowriter where the author can play through and test the interactive narrative in progress; an essential part of the authoring process and creative feedback loop.

[25] Terms used in the global scope, or within a particular scope, of a computer program must be unique to avoid errors or unpredictable behaviour.

Emoviz - an animated visualisation of a digital actor's dynamic emotional data, hence 'emoviz', making their emotional performance visual. The emoviz feature is used in multiple places: in the Playtester, in the 'PAD emoviz' dashboard, and will appear in the Convoplayer.

Story Data: the Nouns

Generally, these nouns refer to the narrative data and entities that I write to the database during the story data authoring process. I'm referring, here, to the narratological distinction I made earlier between the story and the narrative discourse - i.e. the story is the data and the discourse is that story data as manipulated by processes such as my interactive storytelling algorithms and user interaction.

Nouns referring to fictional characters

Actor - any character in the cast of the interactive narrative: 'actor' rather than 'character' because they perform and act interactively and also to avoid any confusion with alphanumeric characters.

Protag - protagonist and player character: 'protag' rather than 'player-character' because, in videogames, the latter usually refers to an avatar.

NPC - non-player character, a common abbreviation in videogame parlance.

Actor Name - e.g. Joel, Sarah, Hannah. As is usual in fiction or drama, my main characters have proper names, but the digital actor's name also serves other functions in code - e.g. it's used to invoke the appropriate visual representation of the specific actor.

Nouns referring to structural and steering concepts

The relationship between the steering-a-course mechanic and how the story data is structured is convoluted[26]. Here, I focus on the most salient features at the scene level

[26] For instance, not all the data is stored to the database in the same way at authoring

(see figure 26).

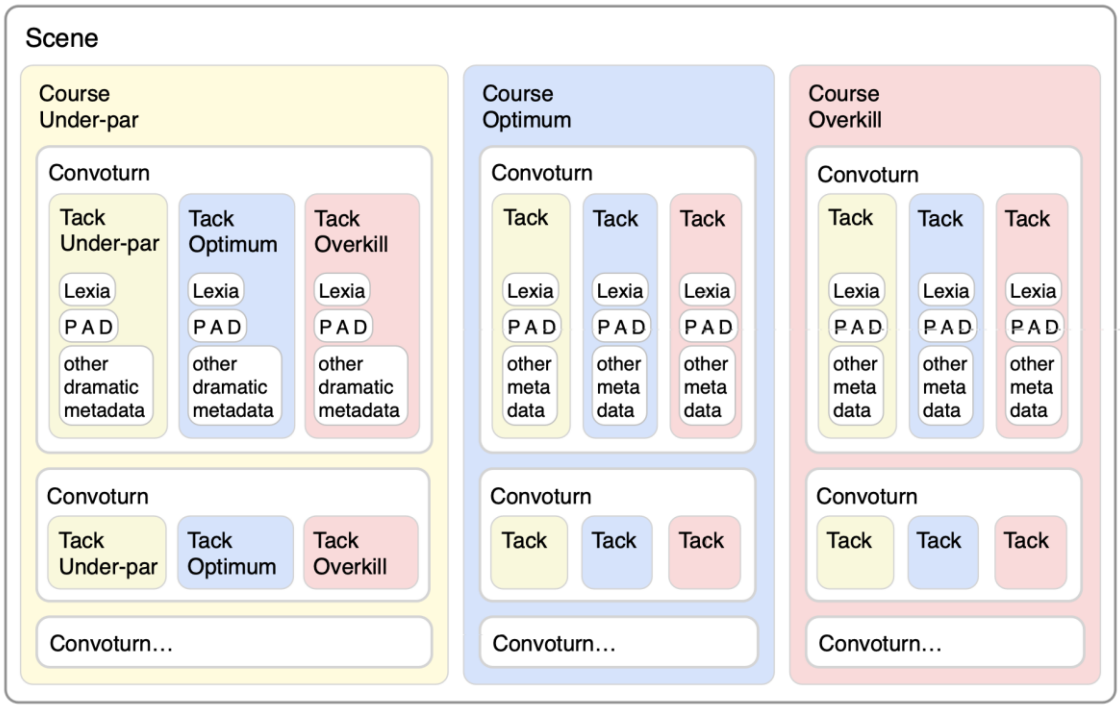

Figure 26. Diagram of the story data structure of a scene

Scene - a scene is a container for one or more courses (see below) but you can only play a single course in a scene. As such, a scene contains a unit of continuous narrative action, hence the drama terminology. Scenes in my interactive narrative generally occur in a linear sequence, although the sequential linearity may break apart towards the climax.

Course - a unit of continuous action nested within a scene: 'course' because you steer a course through the narrative from scene to scene. Possible course types are Optimum (default), Under-par and Overkill.

Convoturn - each course contains a sequence of convoturns, which are the turn-by-turn actions/reactions of the digital actors, as in a conversation (even if it's an interior monologue), hence the name. In each convoturn, an actor performs one action of a specific type and also expresses an emotional state (via the emoviz). The types of action

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time, some is stored locally at runtime.

a protag can perform are: speak, think or ponder (see verbs below); but an NPC can only speak.

Tack (as a synonym for course) - since steering-a-course is a recursive pattern, you can change tack from convoturn to convoturn within a course. So each convoturn may contains tacks that can be of type Optimum (default), Under-par or Overkill.

Lexia - a unit of onscreen text, which represents either an actor's speech or thought (including thoughts they are pondering over) for each tack within a convoturn. I chose 'lexia', a unit of reading, rather than 'text', because the latter is used extensively in code for other purposes.

P A D and **Dramatic** - each tack within each convoturn contains the lexia and its accompanying emotional (Pleasure-Arousal-Dominance) and dramatic metadata, which governs the emoviz and the (animated or timed) performance of the lexia respectively.

Verbs: What can the Actors do?

The following verbs designate functions, types of behaviour. However, the domain-specific language alone doesn't provide a complete answer to the question posed. I'll come back to that momentarily.

Speak and **think** - when an actor speaks or thinks, it produces a lexia on screen.

Ponder and **choose** - when an actor ponders, it also produces a lexia on screen but in the form of thought options for the reader-player to choose. I arrived at 'ponder' because a convoturn, composed of a ponder, is a juncture in the scene when the reader-player has to make a choice on behalf of the protagonist (protag). 'Ponder' seemed the most apt description of what the protagonist and the reader-player are actually doing at that point in time.

Emote PAD - is the function of emitting the pleasure (P), arousal (A) and dominance (D) values that are used to simulate the expression of emotion in the actor's emoviz,

hence 'emote.'

Superficially, there may appear to be only a small number of verbs for the digital actors to perform or do, but the purview of these actions can be extensive. In stories centred on human (or human-like) relationships, what characters think, say and decide often has profound narrative power due to the arising implications. Potentially, any kind of action can be inferred from (or read into) a speech or thought act. For example, if Sarah thinks, "Run away!", and the reader-player is given no evidence to the contrary, they will assume she takes this action. I don't have to convince the reader-player by implementing a visual simulation of Sarah running, the reader-player simply and efficiently constructs the action for themselves, mentally. But that's not all, if we bring theory of mind into play, the potential ramifications of these five verbs - speak, think, ponder, choose and emote - are significant, reverberant and far-reaching.

Also, with regard to the reader-player, superficially, it may seem that all they can actually *do* is make choices; but that would be to ignore the powerful effects of narrative empathy (see Keen, 2013). Furthermore, the act of making non-trivial decisions on behalf of the protagonist (especially 'in character') could be a particularly intense or captivating experience.

Reflections

Dynamic black boxes and steering a course through *Stitched Up*

Within my interactive narrative, *Stitched Up*, the story and discourse constitute an interplay of cybernetic observing systems. To give an idea of how these observing systems operate, I will consider some of the black boxes that are embedded within the fictional world or induced through interaction. The purpose of a black box is to make sense of something opaque or confusing by observing inputs and outputs and detecting a pattern that seems to offer an explanation. *Stitched Up* offers various kinds of black boxes, giving order and form to the mishmash of stuff that makes up the characters and storyworld, for the construction of narrative meaning.

Joel is held captive, after a one-night stand in a strange city. Meanwhile, Sarah, who refuses to believe that Joel has simply left her, sets out to find him and is befriended by Hannah, who appears to help her. The story-game progresses through conversations and interrogations that range from (apparently) benign and friendly to vindictive and cruel. This process causes both Sarah and Joel, separately, to reflect on their troubled relationship, to reinterpret their memories and reevaluate what's important in their lives.

This narrative configuration gives rise to a number of black boxes or possible worlds at the outset. Sarah needs to find Joel but she also needs to work out what went wrong in their marriage and if it's worth saving. She also wonders how far she can trust her new friend. Joel needs to find out what his captor wants and if he can persuade her to let him go. He is also baffled by why he slept with Hannah in the first place.

All the characters are black boxes to each other and to the reader-player - even Sarah and Joel, who are the only characters whose thoughts the player can read. The reader-player has to make decisions, playing as Sarah or Joel, based on what they consider to be viable explanations (functional descriptions) for the black boxes they encounter (e.g. What motivates this character? What do they want? Why are they behaving the way they are? How can they achieve their goals?) Their choices have narrative consequences, which in turn may support or challenge their functional descriptions of

the narrative black boxes they are currently contemplating. This circular process forms a cybernetic narrative system.

Stitched Up is a story moving forwards in time as well as going backwards into memory. As Joel and Sarah try to achieve their goals (e.g. escape and rescue, respectively) they are forced to reevaluate their past histories. This, in turn, affects their future because how they interpret their memories, or how they re-remember, affects the decisions they make. So, the characters, themselves (or more accurately, the reader-player 'in character'), apply a black box to their memories to try to make sense of 'the mess' of their pasts. Depending on the kinds of explanations that the reader-player chooses for the narrative black boxes they encounter, they will steer a different course through the story.

Hannah is a key influence in this respect. She is an unreliable narrator of her own history and, sooner or later, the reader-player realises that she misrepresents Joel and Sarah to each other. Nevertheless, if the protagonists (and reader-player 'in character') are swayed by Hannah's interpretation of events, they'll veer off the Optimum course. In this case, they will have failed to maintain strong metarepresentational source tags - e.g. 'Hannah claims that...' such and such (see Zunshine, 2006). The Under-par and Overkill courses are governed by choices where Joel and Sarah have succumbed to Hannah's influence, where their thoughts and feelings have been contaminated by her distorted judgements. This is where applying Theory of Mind in my steering-a-course interactive fiction is markedly different from a linear narrative (whether print, screen or stage). How the reader-player applies their theory of mind to the narrative black boxes and possible worlds they encounter materially affects the course of the story.

On using the Convowriter

Now I'll consider how building and using my own tool, the Convowriter, has influenced and facilitated my creative writing. First, I'll analyse the different stages of my digital creative writing process, by which I mean, the writing of the story data that will become the 'surface' (Wardrip-Fruin, 2009, p. 12) or *texte-à-voir* (Bootz, 2005, para. 15).

Writing the first draft of the story data, I found, involves a number of phases. The first

phase is structuring the interactive narrative into scenes and courses, working out how the latent story flows through the Optimum, Under-par and Overkill courses. The second, is writing the content of the scenes' courses: the convoturns. This stage also tends to fall into two distinct phases, which I'll call traversals. The first traversal is where I focus on the words, I write the convoturns' lexia. The next traversal is going back through the course's convoturns and adding the emotional Pleasure-Arousal-Dominance (PAD) values and other dramatic metadata, all of which affects the dynamic and expressive performance of the lexia. So the first traversal is a relatively conventional writerly process, the emphasis is on the words; but the second traversal, where I'm adding dramatic instructions for my digital actors to perform (e.g. emote anger/fear, speak quickly, pause), is more like being an actor-director. I'm both directing the drama and interpreting and vicariously performing the actor's lines.

It's somewhat ironic that, after writing the text (into the database), I go back through it to produce and encode an emotional interpretation of it so that the computer can perform a simulation of those emotions in an artificial language of visualisation. Also, the visual qualities of the animation are yet another type of intersemiotic and intermedial translation of emotional data into emotional expression. As author, I'm enwrapped within a curiously recursive process of human-computer interaction, an oddly observing system (harking back to Glanville), passing back and forth between, or through, a permeable Russian dolls' nest of black boxes - because the work on the dramatic performance doesn't stop there.

When I select PAD values for the lexia, they may seem dramatically and emotionally appropriate but, sometimes, when I view the scene-course in the Playtester, the actual performance of the animation, driven by these values, doesn't seem quite right emotionally. For instance, perhaps it's too agitated, too lethargic, or the pattern of motion doesn't express the particular quality of affectivity I want. It may be a matter of altering the PAD values but, if I'm confident the PAD configuration is appropriate, then it's the emoviz animations that need to change. An animation I developed in the PAD emoviz (dashboard) feature of my Convowriter[27], when put to work in the context of a digital actor performing the narrative, may not be as effective as it seemed to be 'in the

[27] Or 'Dashsti' an earlier prototype of the Convowriter.

lab.' In which case I need to edit the code that runs the emoviz animations to produce a more fitting dramatic performance.

Future research and developments

The iterative process of writing, coding, designing, editing, re-writing, refactoring code, etc., is complex and time-consuming, hence the current minimum viable product status of both my interactive digital narrative platform, The *Conversengine*, and my interactive digital narrative, *Stitched Up*. There is much that I want to further improve and develop.

Regarding the Conversengine, future developments include:

- Improve the emoviz system - enhance the animations and improve their emotional expressivity.
- Implement the Convoplayer - the public-facing feature for playing published interactive narratives.
- Improve the Convowriter user experience - includes many planned user interface improvements.
- Improve the Playtester narrative play-testing experience - e.g. incorporate some of the Convoplayer game logic.

With regard to *Stitched Up*, the fictional character, Hannah, poses a particular challenge for me as the writer. I have to make her sufficiently persuasive and/or charismatic if I want the steering-a-course mechanic to work well. I won't know whether I've achieved that until a later stage of development, beyond the minimum viable product, when I'll be able to gather user feedback about the courses steered through the narrative. In addition, future research questions could include: how do reader-players generally respond to steering courses? Are all the courses navigated to some degree or other, or are some mostly neglected?

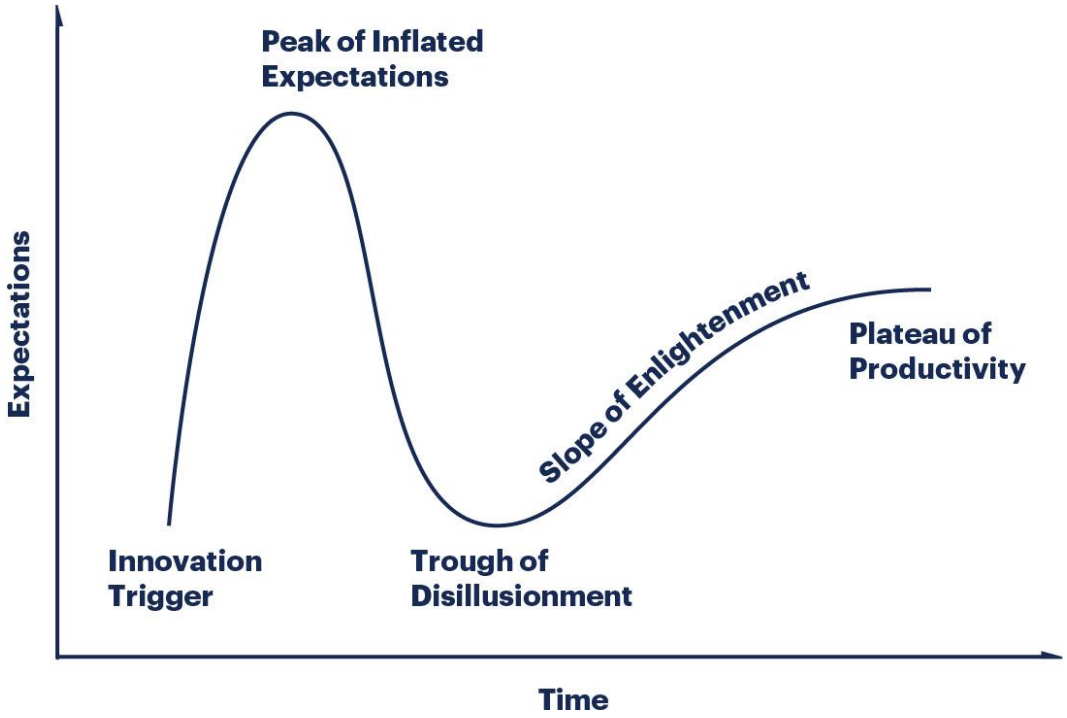

Figure 27. Gartner Hype Cycle

When I started developing *Stitched Up*, I had a naive mental model of what I thought I could achieve with programming. I wanted to model my fictional characters as black boxes in code. In hindsight, I can see how my progress reflects the Gartner Hype Cycle (2019) - see figure 27. Initially, I was terrifically excited by my personal "Innovation Trigger," expecting a major breakthrough in combining computation with my interactive narrative ideas. Eagerly developing theories, I rose to a "Peak of Inflated Expectations" then, as I tried to put theories into practice in code, I sank into a "Trough of Disillusionment" when my initial experiments failed (on my terms). But I persisted and gradually clawed my way up the "Slope of Enlightenment" to, at last, reach a "Plateau of Productivity" by working with more realistic expectations and practical implementations of my ideas (Gartner, 2019).

The black box as a representation of a fictional character does not reside in the actual code but in the *process* of interactive storytelling, in the way fictional characters are constructed dynamically from the narrative, first by the writer, then by the reader. Indubitably, this involves code - and just like any code base, mine makes use of

encapsulation (black box pieces of code) - but the black box of the fictional character is not sealed up in the code.

While the reading of any narrative requires the reader to participate in the construction of the character from the text, the reading and playing of an interactive narrative, such as *Stitched Up*, requires their *concrete* participation as well as their intellectual and emotional participation. The kind of character that emerges depends on the choices the reader-player makes as they play through the narrative. As McKee argues in relation to film and television screenwriting, "the only way we ever come to know characters in depth is through their choices under pressure" (1999, p. 103). So, if a reader, playing 'in character' as a protagonist of *Stitched Up,* is faced with multiple (non-trivial) choices, then there are multiple potential ways for the character to develop - in the sense of the character being transformed by their experiences - which is what gives them depth.

The consequences for the writer are significant. Since I'm writing emergent characters, I'm conscious that different choices will transform the same character in different ways. So much so, that by the end, there could be, essentially, different versions of the same character. This means that the black boxes and possible worlds, rather than being reified in code, are in the nebulous territory between code and narrative, between the minds of writer and readers, between the text (story and discourse) and the mind of the reader and their theory of mind. As I'm writing, I wrestle with these black boxes with the hope and intention that the reader-player will find it engaging to wrestle with them too; albeit in a different way in the Convoplayer, which, unlike the Convowriter, does not literally open up the black box to reveal its inner workings.

In a case such as *Stitched Up*, the interactive characters, with all their varying potential, are created in the story data, via a writerly process, but they only emerge through the process of interactive storytelling, which involves a different kind of creative authoring work. The whole enterprise involves a melding of the imaginative work of the fiction writer with the imaginative work of the programmer and the artist/designer because the algorithms and the visuals affect user interaction (the reader-player) and the reader-player's choices affect the course of the narrative.

I look forward to seeing what AI brings to interactive digital narrative in the future, but I've found that the magic of interactive narrative lies just as much in the narrative realm as it does in the computing realm, if not more so. But that's not to underestimate what computing brings to text-based interactive storytelling. Bearing in mind *Amara's law*: "We tend to overestimate the effect of a technology in the short run and underestimate the effect in the long run" (Wikipedia, 2019b, para. 4), computing brings more than superficial enhancements. Interactive fiction is still in its relative infancy and there is much yet to explore. I made it my mission to discover for myself, as a creative artist, what computing can bring to my interactive storytelling and the reader-player experience. Rather than leaving computation as a black box (for example, by using an extant game engine or authoring tool), I wanted to open the black box of the computer program and rummage around in it to see what I could find, to see if there was anything I could invent. In this way, I was able to answer my research question of how to model a convincing interactive character, with apparent psychological depth and a rich emotional life, in a playable digital narrative using expressive programming and multimodal languages, including natural language.

Conclusion

In conclusion, I have shown how a convincing interactive character, with apparent psychological depth and a rich emotional life can be modelled by simulating fictional minds, in terms of the characters' thoughts, speech and emotional responses. Rather than being an interactive narrative, *Stitched Up* is more accurately described as an interactive *drama* that employs textual techniques associated with the novel and short stories. Its fictional characters are constructed textually, as in the novel, but through a process of enactment rather than narration.

Most text-and-choice-based interactive narratives use narration and the few that do not, the few that rely entirely on diegetic lexia, use skeuomorphic representational designs (e.g. text messages, emails) to rationalise or literalise the onscreen text. *Stitched Up*, uniquely, allows onscreen lexia to simply be the thoughts or speech of the fictional character, to enact thought and speech directly in the diegetic realm, unmediated by any form of skeuomorphism, thereby fostering greater intimacy between reader-player and fictional character. Furthermore, the lexia are embedded in the same visual field and on the same diegetic and ontological plane as the dynamic abstract visualisation, which enacts the character's emotional state in sync with their thoughts or speech, thus, metaphorically fleshing out the character. This combination of directness and expressiveness places the reader-player in the mind of the protagonist, potentially leading to enhanced empathic identification and agency and, therefore, a more profoundly immersive experience. This is particularly important in a choice-based interactive narrative, such as *Stitched Up*, where the reader-player has to make choices on behalf of the protagonists.

These features constitute a new form of expressive dynamic digital language for portraying interactive characters with psychological depth and rich emotions. Later, I considered the computational processes involved in modelling emotions and how my chosen emotional paradigm is founded upon existing psychological research. I also discussed how the visualisation design and its ability to evoke emotion, via abstraction, colour, shape and motion, is equally well-founded in existing research. This gives me confidence that the new expressive multimodal language I have developed will work

effectively to evoke fictional characters for reader-players.

Comparing theories from narratology and those of a range of writers (novelists, dramatists) who have written about creating fictional characters, I discussed what makes a character complex and psychologically deep and I have shown how these qualities manifest in the main characters of *Stitched Up*. An important (although not always essential) aspect of character complexity is character development, which is necessarily linked to dramatic structure. I have shown how character development in *Stitched Up* is tied up with the *Conversengine's* unique *steering-a-course* ludonarrative structure. Therefore, the way the characters develop depend on the choices that the reader-player makes, which determine the course of the narrative.

By identifying and exploring the commonalities between the theories of the black box from cybernetics, and possible worlds and theory of mind from narratology, I have shown how these concepts influenced the design of the *Conversengine*, an original ludonarrative engine that produces a distinctive cybernetic interactive narrative structure. In effect, what the fictional characters say, think and emote provides the narrative system feedback. This combination of enacted diegetic lexia and emotional visualisation influences the reader-player's choices in a feedback loop that steers an individualised course through the narrative and significantly affects character development. The underlying structural courses (*Under-par, Optimum, Overkill*) reflect different ethical and temperamental values, leading to different narrative outcomes.

When innovating in the realm of interactive storytelling and ludonarrative design, it's important to have the appropriate tools at one's disposal to facilitate a productive and fluid iterative creative flow. However, my review of existing authoring tools demonstrated a need for a new tool to fulfil the arising specific requirements of this endeavour. I explained why I decided to build an authoring tool and outlined its distinctive features. Delving into the narratological distinction between story and discourse, I showed how an understanding of these concepts has practical application when designing an authoring tool. I also discussed how the tools a creative artist uses can limit what they're able to create by proscribing the expressive language or languages (natural and multimodal) they are able to use. I then discussed the original domain-specific language (DSL) I have devised for the *Conversengine* and how it both describes

and defines the unique features of the ludonarrative system. By virtue of being a shared, ubiquitous language that works across the different domains of creative writing and coding interactive narratives, this DSL meets the expressive and computational needs of the whole creative project.

Eventually, in the future, the *Conversengine* will become a publishing as well as authoring platform for *Stitched Up* and other works. I have shown how building tools to meet your own needs, but with the conscious intention that others may find them useful, is a common strategy in software development, exemplified by some notable examples in the field of interactive storytelling. I hope the platform and tools I have built will be of benefit to other digital writers in the future. I also hope that *Stitched Up* - alongside my earlier works that explore fictional and non-fictional minds, memories and emotions, such as *Fitting the Pattern* (2008a), *Tailspin* (2008b), *Underbelly* (2010), *Rememori* (2011) and *Inkubus* (Campbell and Wilks, 2014) - becomes a valuable practice-based example of an interactive narrative built with the *Conversengine*.

Together all these features of the *Conversengine* - the expressive language of diegetic textual enactment; the abstract emotional visualisation system (*emoviz*); the *steering-a-course* structural ludonarrative engine that can determine character development; and the dedicated, integrated authoring tool - constitute a new development in the field of interactive digital narrative, especially where complex, psychologically deep and emotionally expressive interactive characters are concerned. This original contribution to the field of text-based interactive dramatic storytelling opens up more potential for a greater variety of expressive modes and a greater range of genres, thematic concerns and approaches to storytelling in interactive dramatic fiction. In short, it expands the range of what is possible in the field.

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Emotion / Emotional State	P	A	D	P value	A value	D value	Mood Octant	HUMAINE Emotion Classification	Plutchik's Wheel of Emotions	Tomkin's Basic Emotion Ranges	Parrott Emotion Classification	Ekman's Basic Emotions
_Bored	-	-	-				Bored	Negative & passive				
bored / boredom	-	-	-	-0.65	-0.62	-0.33	Bored	Negative & passive				
cynicism	-	-	-				Bored ?		disgust + anticipation			
depressed	-	-	-				Bored					
despair	-	-	-				Bored ?	Negative & passive	fear + sadness			
dissappointment	-	-	-				Bored ?	Negative & passive	suprise + sadness			
distress	-	-	-	-0.40	-0.20	-0.50	Bored			distress - anguish		
dull	-	-	-				Bored					
fatalism	-	-	-				Bored ?		anticipation + trust			
helplessness	-	-	-				Bored ?	Negative & not in control				
inhibited	-	-	-	-0.54	-0.04	-0.41	Bored					
lonely	-	-	-				Bored					
pessimism	-	-	-				Bored ?		sadness + anticipation			
pity	-	-	-	-0.40	-0.20	-0.50	Bored					
powerlessness	-	-	-				Bored ?	Negative & not in control				
resentment	-	-	-	-0.20	-0.30	-0.20	Bored					
sad / sadness	-	-	-	-0.70	-0.20	-0.50	Bored	Negative & passive	primary emotion	distress - anguish	primary emotion	core emotion & universal facial expression
_Disdainful	-	-	+				Disdainful					
contempt	-	-	+				Disdainful ?	Negative & forceful	disgust + anger			universal facial expression & additional basic
indifferent	-	-	+				Disdainful					
reproach	-	-	+	-0.30	-0.10	0.40	Disdainful					
selfish	-	-	+				Disdainful					
uncaring	-	-	+	-0.32	-0.12	0.28	Disdainful					
unconcerned	-	-	+	-0.13	-0.41	0.08	Disdainful					
uninterested	-	-	+				Disdainful					
_Anxious	-	+	-				Anxious	Negative & not in control				
aghast	-	+	-				Anxious					
alarm	-	+	-				Anxious ?		fear + surprise			
anxiety	-	+	-				Anxious ?	Negative & not in control	anticipation + fear			
bewildered	-	+	-				Anxious					
dissapproval	-	+	-				Anxious ?		suprise + sadness			
distressed	-	+	-	-0.61	0.28	-0.36	Anxious					
doubt	-	+	-				Anxious ?	Negative thoughts				
embarrassment	-	+	-				Anxious ?	Negative & not in control				additional basic emotion
envy	-	+	-				Anxious ?	Negative thoughts	sadness + anger			
fear	-	+	-	-0.64	0.60	-0.43	Anxious	Negative & not in control	primary emotion	fear - terror	primary emotion	core emotion & universal facial expression
frustration	-	+	-				Anxious ?	Negative thoughts				

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guilt	-	+	-				Anxious ?	Negative thoughts	joy + fear			additional basic emotion
humiliated	-	+	-				Anxious			shame - humiliation		
hungry	-	+	-	-0.44	0.14	-0.21	Anxious					
hurt	-	+	-				Anxious ?	Negative & passive				
in pain	-	+	-				Anxious					
insecure	-	+	-				Anxious					
puzzled	-	+	-	-0.41	0.48	-0.33	Anxious					
remorse	-	+	-	-0.30	0.10	-0.60	Anxious		sadness + disgust			
shame	-	+	-	-0.30	0.10	-0.60	Anxious	Negative thoughts	fear + disgust	shame - humiliation		additional basic emotion
shock / startle	-	+	-				Anxious ?	Agitation		surprise - startle		
stress	-	+	-				Anxious ?	Agitation				
tension	-	+	-				Anxious ?	Agitation				
unbelief	-	+	-				Anxious ?		surprise + disgust			
upset	-	+	-				Anxious					
worry	-	+	-				Anxious ?	Negative & not in control				
_Hostile	-	+	+				Hostile					
aggressiveness	-	+	+				Hostile ?		anger + anticipation			
angry / anger	-	+	+	-0.51	0.59	0.25	Hostile	Negative & forceful	primary emotion	anger - rage	primary emotion	core emotion & universal facial expression
annoyance	-	+	+				Hostile ?	Negative & forceful				
antagonistic	-	+	+				Hostile					
belligerent	-	+	+				Hostile					
catty	-	+	+				Hostile					
cruel	-	+	+				Hostile					
defiant	-	+	+				Hostile					
disgust	-	+	+	-0.70	0.70	0.10	Hostile ?	Negative & forceful	primary emotion	disgust & dissmell		core emotion & universal facial expression
dominance	-	+	+				Hostile ?		anger + trust			
hate	-	+	+	-0.60	0.60	0.30	Hostile					
hateful	-	+	+				Hostile					
hostile	-	+	+	-0.42	0.53	0.30	Hostile					
insolent	-	+	+				Hostile					
irritation	-	+	+				Hostile ?	Negative & forceful				
nasty	-	+	+				Hostile					
outrage	-	+	+				Hostile ?		surprise + anger			
violent	-	+	+	-0.50	0.62	0.38	Hostile					
_Docile	+	-	-				Docile					
calm	+	-	-				Docile ?	Quiet positive				
consoled	+	-	-				Docile					

Emotion / Emotional State	P	A	D	P value	A value	D value	Mood Octant	HUMAINE Emotion Classification	Plutchik's Wheel of Emotions	Tomkin's Basic Emotion Ranges	Parrott Emotion Classification	Ekman's Basic Emotions
content / contentment	+	-	-				Docile ?	Quiet positive				additional basic emotion
gloating	+	-	-	0.30	-0.30	-0.10	Docile					
politeness	+	-	-				Docile ?	Reactive				
protected	+	-	-	0.60	-0.22	-0.42	Docile					
relaxed	+	-	-				Docile ?	Quiet positive				
relieved / relief	+	-	-				Docile ?	Quiet positive				additional basic emotion & sensory emotion
sentimentality	+	-	-				Docile ?		trust + sadness			
serene	+	-	-				Docile ?	Quiet positive				
sleepy	+	-	-	0.20	-0.70	-0.44	Docile					
submission	+	-	-				Docile ?		trust + fear			
tranquilized	+	-	-				Docile					
_Relaxed	+	-	+				Relaxed					
comfortable	+	-	+	0.85	-0.19	0.13	Relaxed					
leisurely	+	-	+				Relaxed					
optimism	+	-	+				Relaxed ?		anticipation + joy			
satisfied / satisfaction	+	-	+				Relaxed	Positive thoughts				additional basic emotion
sensory pleasure	+	-	+				Relaxed ?					additional basic emotion & sensory emotion
unpeturbed	+	-	+				Relaxed					
_Dependent	+	+	-				Dependent					
admiration	+	+	-	0.50	0.30	-0.20	Dependent					
affection	+	+	-				Dependent ?	Caring				
amazed	+	+	-				Dependent					
awed / awe	+	+	-				Dependent		fear + surprise			additional basic emotion
curious / curiosity	+	+	-	0.22	0.62	-0.01	Dependent		trust + surprise			
empathy	+	+	-				Dependent ?	Caring				
fascinated	+	+	-				Dependent					
friendliness	+	+	-				Dependent ?	Caring				
gratitude	+	+	-	0.40	0.20	-0.30	Dependent					
impressed	+	+	-	0.41	0.30	-0.32	Dependent					
infatuated	+	+	-				Dependent					
loved	+	+	-	0.87	0.54	-0.18	Dependent					
morbidness	+	+	-				Dependent ?		disgust + joy			
surprise	+	+	-	0.10	0.80	-0.70	Dependent ?	Reactive	primary emotion	surprise - startle	primary emotion	core emotion & universal facial expression
trust	+	+	-	0.60	0.20	0.10	Dependent ?	Positive thoughts	primary emotion			
wonder	+	+	-				Dependent ?					sensory emotion
_Exuberant	+	+	+				Exuberant					
admired	+	+	+				Exuberant					

Emotion / Emotional State	P	A	D	P value	A value	D value	Mood Octant	HUMAINE Emotion Classification	Plutchik's Wheel of Emotions	Tomkin's Basic Emotion Ranges	Parrott Emotion Classification	Ekman's Basic Emotions
amusement	+	+	+				Exuberant ?	Positive & lively				additional basic emotion
anticipation	+	+	+	0.20	0.20	0.30	Exuberant ?		primary emotion			
bliss	+	+	+				Exuberant ?					sensory emotion
bold	+	+	+	0.44	0.61	0.66	Exuberant					
carefree	+	+	+				Exuberant					
courage	+	+	+				Exuberant ?	Positive thoughts				
creative	+	+	+				Exuberant					
delight	+	+	+				Exuberant ?	Positive & lively	joy + surprise			
dignified	+	+	+	0.55	0.22	0.61	Exuberant					
ecstacy	+	+	+				Exuberant ?					sensory emotion
elated / elation	+	+	+	0.50	0.42	0.23	Exuberant	Positive & lively				
excited / excitement	+	+	+				Exuberant	Positive & lively		interest - excitement		additional basic emotion
gratification	+	+	+	0.60	0.50	0.40	Exuberant					
happy for	+	+	+	0.40	0.20	0.20	Exuberant					
hope	+	+	+				Exuberant ?	Positive thoughts				
interest	+	+	+				Exuberant ?	Reactive		interest - excitement		additional basic emotion
joy / happiness	+	+	+	0.40	0.20	0.10	Exuberant	Positive & lively	primary emotion	enjoyment - joy	primary emotion	core emotion & universal facial expression
love	+	+	+	0.30	0.10	0.20	Exuberant	Caring	joy + trust		primary emotion	
pleasure	+	+	+				Exuberant ?	Positive & lively				
powerul	+	+	+				Exuberant					
pride / pride in achievement	+	+	+	0.40	0.30	0.30	Exuberant	Positive thoughts	anger + joy			additional basic emotion
triumphant	+	+	+				Exuberant					
vigorous	+	+	+				Exuberant					

Sources:
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