Perceptual Narrowing: Enhancing Realism in Autonomous Character Interactions

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ABSTRACT
This paper provides a survey of the works of noted author Malcolm Gladwell and his works in documenting the impact of group interaction and individual behavior on human cognitive abilities. The overriding theme in most of Gladwell's work is the effect that the minutiae have on human decision making. This paper will first provide an overview of Gladwell's major works (The Tipping Point and Blink), as well as his many articles written for The New Yorker. It will then describe the work done by the ACE group with regards to the Virtual Raft Project and specify a design that incorporates one of Gladwell's themes into the project thus enhancing the realism in the interactions of autonomous characters.

Categories and Subject Descriptors
D.3.3 [**Biomorphic Computing**]: Autonomous Characters, Human Computer Interaction, Cognitive Theory.

General Terms
Human Factors, Bioinformatics, Arts

Keywords
Bioinformatics, Malcolm Gladwell, Virtual Raft Project

1. INTRODUCTION
Malcolm Gladwell, the NYTimes best-selling author of books like The Tipping Point and Blink, has spent much of his work trying to ponder the nature of human decision making, and how the seemingly innocuous and minutiae play a major role in human cognitive ability. His works don't propose any new interaction methodologies or communication techniques, but seek to quantify the existing patterns of human interaction and provide a lucid interpretation for the reader. This paper will provide an overview of this quantification and propose how some of these patterns can be used to enhance the human-like behavior of autonomous characters.

2. The Works of Malcolm Gladwell
Gladwell is a prolific writer on the mystery of human nature. He has written numerous articles and books on how people think, act, and react to external stimuli. He tries to bring forth the subconscious decision making process that we all go through but few are aware of, and even fewer can describe. His works try and use examples and case studies to discuss the effects of natural instincts as well as the role of enculturation in the decision making process. This section briefly describes some of these effects in terms of major themes.

2.1 Choking and Panic
In [3] Gladwell acknowledges that many humans falter under pressure, however for different reasons. He draws distinction between "choking" where in the brain fails to make rational choices due to an information overload, and true panic where in there is a perceptual narrowing and the brain ceases to process all the information available to it.

2.1.1 Choking at the Wimbledon

To further elucidate the difference, Gladwell uses the now famous 1993 Wimbledon final between Jana Novotna and Steffi Graf to show the true nature of "choking". Jana Novotna had an upper-hand in the match, however as she was serving for the match, the pressure of the moment, and the importance of the serve set in, and she began to over- think her movements and serves, and committed mistakes that a player of her caliber should never had made. These mistakes made her doubt herself even more, and only protracted her mistakes. She ultimately lost the match, not because of Graf's superiority, but of her cracking under pressure.

Gladwell argues that most of people of creatures of habit, and typically indulge in implicit learning where in the brain is, subconsciously, looking for repeatable patterns. This learning is outside the realm of awareness, i.e., the subject is not consciously aware of this learning. However, sometimes during stress, explicit learning takes over, and leads to choking. In Novotna's case, she began evaluating her basic movements like serves, lobs etc and ended up losing her fluidity and touch and hence the championship.

2.1.2 Panic under Water
Gladwell cites the first scuba-diving experience of Ephimia Morphew, a Human Factors expert at NASA. After weeks of training, she went for her first solo dive with another student. As part of the exercise, she was to replace her regulator under water with a spare one—a standard procedure. During the exercise, after replacing the regulator instead of getting in fresh air, she got water. Her brain experienced a perceptual narrowing where her thought process was reduced to one recurring motive: to get air. She forgot that she had a working regulator that she had just replaced. The stress induced by the situation wiped out her short-

term memory. Also, her lack of experience in solo scuba diving as the residual memory from experience helps to hold on to that short-term memory and she reached out for her partner's regulator and in the process endangered both their lives. In retrospective, she realizes there was no logical basis for her actions, nevertheless her brain refused to evaluate all the information that was available to her and submitted to the primal instinct to survive..

The above two examples show how contrasting panic and choking are. While choking is the result of thinking too much, panic is the result of thinking too little. Choking is the loss of instinct, and panic is the sole reliance on instinct (i.e., survival).

2.1.3 How to tell the Difference: The John Kennedy Jr. Tragedy

Armed with the concepts of panic and choking Gladwell attempts to dissect the 1999 crash of John F Kennedy Jr's plane off the coast of Massachusetts. He provides a detailed explanation about night flying and the challenges of flying by instruments and the traps that a can easily fool an inexperienced pilot. One of the biggest challenges in nigh-time flying is the lack of a physical frame of reference, i.e., the horizon. Every time a plan banks for a turn, it is in effect loosing altitude. Pilots implicitly correct this as they usually have a visual reference of the horizon. More experience pilots also know how to fly by instruments alone, and correct this fundamental property of aviation. Gladwell, through a detailed study of the NTSB account, proceeds to explain how, due to JFK Jr's inexperience with night-flying, he didn't realize that with every turn he was loosing altitude as well as turning away from the land lights. As he was focused on trying to find land lights, he didn't pay attention to his instruments that should have shown him that he was slowly but surely losing altitude.

Based on the NTSB report, Gladwell argues that the frequent turns of the airplane (almost every 30 seconds) shows that Kennedy panicked as he was desperately trying to find the lights of Martha's Vineyard. If he had choked, he would have gone into explicit learning mode and his movements would have been a lot more deliberate and practiced. Gladwell theorizes that towards the end, Kennedy was so focused on finding the lights of Martha's Vineyard, that he must have ignored the high winds and other tell-tale signs of lowered altitude.

Gladwell aptly summarizes that while Panic is conventional failure brought on by lack of experience, Choking is paradoxical failure as it is brought on by the doubting of experience due to the stress brought upon by the situation. If Kennedy had waited another year before flying solo in the night, he would have known how to interpret the instrument clusters, ignore his instincts, and trust his training.

2.2 The Warren Harding Factor

2.2.1 Tall, Dark, and Handsome: The 29th President

Warren Harding is widely regarded as the worst President in US history. Not only were there no major accomplishments in his three years in office, his administration was riddled with scandal and corruption. While he himself was well-liked, he was known to be indecisive and weak. In [6] Gladwell attempts to explain the rise of this lack-luster politician and coins the term "The Warren Harding Factor".

While intellectually hollow, Warren Harding was a strikingly handsome man. His head, shoulders, and torso had noticeable proportions and combined with his height and affability gave him an aura of power. In fact, he was many times described as Roman in his looks. Some even suggested he looked presidential. In fact, the older he became, the more presidential he seemed to look. At the same time, he had not noticeable accomplishments in elected office, be it as Councilman, Mayor, or Senator. Hence there was no reason for him to become a Republican Presidential candidate, let alone the president. However, the more the electorate heard him, they saw someone who *looked* presidential enough to be a President. The dark eyebrows combing with the white hair portrayed an image of forcefulness, the healthy skin tone combined with the thunderous voice showed a youthful agility. Hence, from being the last of the 6 Republican candidates he went on to secure the Republican nomination and eventually the Presidency.

Gladwell argues that the election of Warren Harding is the result of first impressions gone wrong. The people were so taken aback by the tall, dark, handsome looks that it led to other connotations such as Harding being a man of courage, integrity, and drive and blinded people from thoroughly evaluating his candidacy. In fact, Harding was popular throughout his presidency. It was only after his death did his lack of leadership, and stories of indiscretions were revealed leading him to be tagged as the worst President in US history.

2.2.2 The Implicit Association Test

Gladwell argues that Harding is just an example of first impressions becoming lasting impression. He cites the Implicit Association Test (IAT) devised by Greenwald, Banaji, and Nosek which aims to test the implicit associations between human beliefs and behavior. The IAT test is given on computer where words and images flash in rapid succession and the subject had only seconds to make the association. Several startling discoveries were made. For example, when classifying careers by gender (i.e., male or female), most respondents associated entrepreneur with male and homemaker with female. What's more, when the word career was pre-associated with female, the respondents took longer to associate the word 'Entrepreneur' with female.

Gladwell himself took a version of this test where in he was given a picture of an African-American male and a European- American male, and asked to associate words to each picture. He was given a very short time interval. In the end, Gladwell ended up associating the words like 'Evil' and 'Hurt' with African-American, and terms like 'Wonderful' with European-American. Gladwell is half black.

Gladwell then undertook his own survey where he polled over half of Fortune 500 companies to find that most of the CEOs were overwhelmingly white, and had an average height of just under six feet. To put this in perspective, while about 58 percent of CEOs are six feet or taller, tall men makeup only 14.5 percent of the male population. He then makes on to make the rather bold statement that to be a CEO its better to be a short white female rather than a short white male. He suggests that height and race are two Warren Harding errors that seem to work to the advantage of the candidates who have both.

Despite the surprising results, the IAT doesn't aim to show the sexist or racist views of its subjects. In fact IAT does not claim to test the conscious values a person may have, but about the implicit beliefs that he or she has.

2.2.3 *Is the Error Inescapable?*

The above studies and observations seem to suggest that committing the Warren Harding error is inescapable. Gladwell begs to differ. According to him, the Warren Harding error occurs when people rely entirely on their snap judgments and let their implicit associations overrule their conscious beliefs.

Snap judgments are created by experiences and the environment which suggests that if the experiences and environments are changed, so can first impressions. For example, one way to change the first-impressions on race would be, as part of a conscious effort to increase interactions with people of other races and familiarize with their culture. Rapid cognition can have good and bad effects, and being aware of it can help improve this task.

2.3 Thin-Slicing

2.3.1 *The Theory of Thin Slicing*

Thin-slicing refers to the ability of the human mind to detect patterns and behaviors based on very little experience. It is perhaps the most problematic of all the rapid cognition behaviors exhibited as interpreted wrong, it can lead to disastrous results.

In [6] Gladwell details the research of John Gottman, a Psychologist with the University of Washington and author of *The Mathematics of Divorce*. Gottman has devised a technique where in after watching a video recording of a couple, he can predict with 95 percent accuracy whether the couple would divorce in 5 years or stay married for 20 years or more. Gladwell first tried his own luck at such estimation only to find that he was accurate only 50 percent of the time. It wasn't like he wasn't thin slicing, but that he wasn't thin slicing enough.

Gottman argues that like handwriting, every relationship has its own distinctive signature that is unique to each pairing. Just like recognizing handwriting is an exercise in pattern recognition, decoding a relationship is a lot about finding patterns of negative and positive interactions. Gottman keeps a detailed count of positive and negative interactions in the video. If the ratio is high, then the marriage is more likely to succeed. Now, since these videos are usually no more than an hour long, he looks out for subtle hints. For example, a response that starts with "Yes, but..." indicates the person is first agreeing but then taking it back, i.e., being defensive. Combination of responses, for example, saying "I don't want to argue about that" combined with the rolling of eyes seems to suggest contempt. The more contempt one sees in the interaction, the more likely the relationship will not last.

Gladwell, armed with this technique proceeded to decode a new set of videos and found his accuracy increase to 80 percent proving that thin-slicing is an innate part of the human psyche, however to use it correctly, one that requires the correct technique. He mentions that humans that are good at thin-slicing are typically peak performers in their field. For example, good basketball players have a good "court sense". Great Generals like Napoleon and Patton had what was called "Coup d'oeil" or the power of the glance i.e., the power to look at the larger scene of the battle field and immediately gauge the position.

2.3.2 *Applications: Program Slicing*

It is interesting to note that slicing is not new to computer science. It has been known that experienced programmers use splicing when attempting to decipher or test programs. In [8], Weiser tries to formalize this splicing by A) providing a definition for a slice and its properties, B) an algorithm for slicing, and C) examples of program splicing. This formalization is much like the technique of thin-slicing for marriages as proposed by Gottman and allows programmers to exploit this natural tendency in testing programs.

2.4 Shortcomings of Gladwell's Work

One salient theme across most of the works it the reluctance of Gladwell to investigate the 'why' in human behavior. He notes the research done in the field by the likes of Antonio Demasio and Nalini Ambady but leaves it at that. He calls the part of the brain that assists in rapid cognition essentially a trap-door that the average reader shouldn't meddle with. In other words, he is promoting the use of empirical data, but does not venture to investigate the source of data. This is perhaps his singular strength for in doing so, he is able to tap into his audience's need to learn more about themselves—the way they think and respond to external stimuli—without concerning themselves with the complex, still little-understood neurological processes.

For example, in [4] Gladwell talks about physical geniuses--people who can seamlessly transfer thought to action and make it seemingly easy. Classified as physical geniuses are people like Wayne Gretsky, Yo Yo Ma, and top notch neurosurgeons. Gladwell briefly goes into explaining the relationship between the basal ganglia that helps control motor action and the actual thought process. He argues that while most people are very good at 'interacting' with their basal ganglia, i.e., choosing which motor skill to use, physical geniuses have the capacity to pick up subtle patterns and use that to accelerate their choice, and increase their effectiveness. The characteristics of the physical genius can be broken down into four complimentary properties, a) visualize the action, b) mentally inspect the image, c) ability to mentally manipulate the image and c) the ability to 'store' the image for reference. He mentions that the physical genius is the product of repetition, where in due to extended periods of practice, this four step visualization process becomes subliminal. So, while Gladwell doesn't go into much details of the 'why', he does provide a pointer for the average reader to become peak-performers themselves.

3. The Virtual Raft Project

The Virtual Raft project is a research project at UC Irvine [1][2] that aims to bring a higher-degree of cross-environment human-computer interaction. The project consists of fixed desktops and mobile tablet PCs that provide an land/water interaction paradigm. Autonomous characters can then move across these PCs when they are brought within proximity of each other.

3.1 Typical Installation

A typical installation consists of multiple desktops that act as islands where multiple autonomous characters can meet around a fire. These autonomous characters can move between islands using rafts over water.

3.1.1 *Islands*

Each island has a fire of a unique color and is at a fixed position, i.e., a desktop PC. In addition of having an IrDA interface to detect rafts, it also has a camera that allows it to detect a human and provide rudimentary machine vision.

3.1.2 Rafts

The tablet PCs act as rafts over water that an autonomous character can use to transfer across islands. All devices are affixed with a singular IrDA device that helps it detect proximity to other islands or rafts. In order to bring realism to the interaction as well as the land/water paradigm, each tablet PC, i.e., raft is affixed with a 2-axis accelerometer that provides the raft real-time feed back about any lateral or vertical movement.

3.1.3 Autonomous Characters

The *virtual* autonomous characters in addition to moving between islands and rafts also respond to the real-world gravity feedback that is provided by the accelerometer by attempting to keep their balance.

3.2 Typical Interaction

A typical installation would involve multiple users that would be concurrently interacting with the system [2]. This installation consists of multiple islands and multiple rafts. Each raft acts as an interface to the system. There are five kinds of roles users can play. The first, *primary interactors* are the ones who physically hold the rafts and transfer the virtual autonomous characters between the islands and rafts and between multiple rafts. Each primary interactor can have multiple *advisors* that closely monitor the raft and provide input. The system also allows for roving *connectors*—users show oversee the interaction between the participants and provide feedback about which islands need need which color character. Then there are *islanders* who align themselves with a specific island and interact with the user via the vision system. *Spectators* are separate from these interactions and observe the system end-to-end.

In an educations setting, one way to increase enjoyment and user involvement is to assign the virtual fire in each island a different color. The end goal was to transfer autonomous characters between the islands in the right number and sequence such that all islands have a fire of the same color (white). The first large scale installation along this lines [2] showed a high level of interaction and enjoyment by the participants. The real-world like interaction with the autonomous characters (due to the land/water interaction paradigm) as well as increase collaboration with other participants contributed to the high level of involvement and collaboration.

3.3 Discussion: The Nature of Autonomous Characters

It is important to note that there is no central computer controlling the system keeping tabs on the location of each autonomous character or raft and providing instructions to the characters. The characters acts independently based on inputs from their virtual world, be it sight (webcam), proximity (IrDA), or gravity (accelerometer). This interaction is much like many flocking theory implementations where in, contrary to popular belief; a flock does not have a predefined leader. Virtual creatures seem to aggregate be it due to migratory, predatory, or survival instincts autonomously along three basic rules, A) move towards the center of the flock, B) match the velocity of their neighbor and C) not collide with their neighbor.

In the next section, an enhancement to the autonomous interaction is proposed based on the works of Malcolm Gladwell. The enhancement uses the concepts of thin slicing to incorporate perceptual narrowing into the characters and increase the life- like response of the system.

4. Enhancing Autonomous Behavior

4.1 Introduction

One way to increase the reality in the interaction with the Virtual Raft project would be to incorporate the concept of perceptual narrowing. This is a challenging but significant enhancement, not the least because by Gladwell's own admission, the core reason, i.e., the 'why' is a little understood phenomenon. However, this lack of understanding of the core reason for the interaction is nothing new for the natural sciences. It shouldn't be an impediment to implementing a basic set of rules to enable rapid cognition in the Virtual Raft's autonomous characters.

4.2 Perceptual Narrowing: Design

In humans, perceptual narrowing is induced by stress induced by the external environment. It effects severely the process of rapid cognition, i.e., thin-slicing, and induces one of two behaviors either panic or choking. Why some people panic, and others choke is a not yet known. However, the feeling of panic is easier to understand as it happens when, due to a stressful situation, the brain starts ignoring all short-term knowledge and starts reverting to long- term knowledge and basic instincts.

Panic and rapid cognition in general rely heavily on past experiences and the current environment. This implies that when in a stressful situation, not only is the brain recalling selective parts of the previous experiences, but also perceives it in new ways.

A complete implementation of perceptual narrowing, in terms of computational complexity is akin to an NP-Complete problem. Not only does it require high number of computing resources, it necessitates a complete, consistent understanding of human cognition--none of which current exist. However, much like transportation specialists who try and resolve routing problems, it is easier to cheat by using knowledge about the domain, and reducing the number of features, to come up with a reasonable implementation.

4.3 Infrastructural Enhancements

In the case of the virtual raft project, this would be possible a) by giving each of the autonomous characters memory, b) providing a unique identity to each raft, and c) enhancing the environmental evaluation rule set of the characters.

4.3.1 Basis for Rapid Cognition: Memory

In the new version of the virtual raft project, each character will keep a record of its interaction with each raft and island. In this record it will store its satisfaction level when at the island or raft. This satisfaction level is determined by the evaluation of previous experience (if any) when on that island or raft. It is important to note that at first instantiation, there is no memory.

4.3.2 The Key to Information Retrieval: Unique IDs

Each raft and island has a unique ID. This is much like the real/world paradigm where each island has a unique global coordinate (latitude and longitude), and usually humans can, after some experience, differentiate between two seemingly congruent objects.

4.3.3 The basis for cognition: Evaluation

The storing and retrieval of data is of little consequence if there are no rules by which they can be interpreted. This section describes the rules of interaction when the character is on a raft and when on an island.

4.3.3.1 Movement Threshold

Currently, proximity to another raft or island automatically results in the character changing its environment. In a real setting, there would be little need to change state unless there was external motivation. Perceptual narrowing will provide that motivation. Each character will have a threshold of instability. If the movement on the raft is below this threshold it will be less inclined to jump to another raft or island and will be inclined to be more selective in its change of state. If the movement of the raft is higher than the threshold, then the character's 'instinct' to find stability will override its need to find the optimal island. This will lead to the character jumping to the nearest possible raft regardless.

4.3.3.2 Color Sensitivity

The movement threshold rule above mentions the notion of an optimal island. An optimal island for a character is where it will be or is the one with a unique color torch. In other words, an optimal island would only have one of each kind of torch.

4.3.3.3 To Stay or to Go: Conflict Resolution

It is very possible that the two rules can result in no movement of characters. For example, if all the characters reach their optimal island, they will have no motivation to jump on to a raft. One mitigation strategy would be to add a boredom factor, where in the longer a character has stayed on an island, its boredom factor increases and so does its propensity to 'jump ship'.

4.4 Usage Scenario

A usage scenario will better help show the effect the infrastructural enhancements described above will have on participants' interaction with the virtual raft.

Upon startup, each island will have random number of characters, each of whom will have randomly assigned movement threshold. With no memory of either the rafts available or their experience on other islands, each character will take the first available raft that comes their way. If the raft moves at a level higher then the character's movement threshold (due to the primary interactor’s extreme shaking of the raft), then the character will automatically look for the nearest stable island or raft. If the nearest island is not optimal, i.e., another character with the same color exists, it will still move to that island as its *instinct* to find stability will override its quest to find the optimal island.

Once the character has found a more stable raft or island and it has the need to change state either in its quest to attain optimality or overcome boredom it will look for the next raft. If the same raft comes by, its memory will dissuade it from jumping on to that raft, and another character from that island will take that raft.

As the rules state, optimality will not result in no movement. Even if by some evaluation path, a character lands on an optimal island, it will keep a count of the time spend on that island. The higher the count, the higher its tendency to move on to an available raft. If there is contention with another character on the island it will be resolved on a first-sight basis where in the first to detect the raft will be the first to board the raft. This also means that the position of each of the characters around the fire also plays a role in their ability to move from land to water.

4.5 Benefits

There are many benefits of incorporating these extra rules that induce perceptual narrowing. Not only does it enhance realism when interacting with the system by showing the life-like tendency of the characters to look for stable ground when on water, but the variants of this version can be used in educational technology.

For example, this version can be easily modified to show the depletion of the ozone layer. In such a simulation, each island would represent groups of oxygen molecules and each of rafts would be groups of ozone molecules. Occasionally, a highly unstable raft, i.e., a CFC agent would come along, and result in one of the Ozone molecules breaking down to form oxygen, i.e., moving on to an oxygen island. As the number of CFC agents increase, the number of ozone molecules will decrease as the oxygen molecules will not feel the motivation to increase their molecular number to three. In this instance, the advisors (i.e., the teachers) will encourage the primary interactors to increase the movement in their rafts and become the CFC agents and see first-hand the effect they have on the ozone layer.

4.6 Perceptual Narrowing: Implementation

Perceptual narrowing is replete with essential complexities due to the domain that is being implemented--human cognition. It is therefore a given that accidental complexities from the implementation are bound to arise. This section outlines some of the hardware and software changes that will need to be made. The list is by no means complete.

4.6.1 Hardware Changes

The single biggest change will be the need to change the Line-of-Sight (LoS) communication protocol—IrDA—with a protocol that allows for 360 degree sensory perception. This perception is needed if the character is to find the next stable raft in its vicinity. One strategy can be to equip each raft and desktop with Bluetooth radios. By virtue of being a radio signal, Bluetooth will allow a spherical sensory perception. Not only will this allow the character to accurately calculate the closest raft, but when on an island, during times of contention (i.e., when there are two characters with the same boredom factor) it will allow it to calculate distance and the closest character will win.

4.6.2 Software Changes

A bulk of the changes will be in the software of the autonomous characters. But some changes will be needed to the infrastructure as well. The software that interprets the movement of the accelerometers will have to in addition to providing the existing data also return a singular value that will indicate the level of stability of the raft. The higher the value the less stable the raft is.

New software will need to be written for both the desktop (islands) and the rafts to interpret distances via the new Bluetooth radio interfaces.

As mentioned, the bulk of the changes will be in the autonomous characters. The major change would be to add a two dimensional matrix that will preserve that will server as its memory. The first column would keep track of each rule, as well as a refuterant list of previous islands and rafts visited. The second column would store the value for each of the values. The other change would be to add to the existing evaluation module the three rules described in section 4.3.3. Also, each of the rafts and islands will need to store their ID and provide it on request.

5. Conclusion

This paper has tried to show two concepts. First provided a survey of the works of Malcolm Gladwell with regard to rapid cognition and then provided a road-map by which the Virtual Raft project can implement the principle of rapid cognition and perceptual narrowing to enhance realism in the interaction of its autonomous characters. The proposed design shows a methodology to implement the process and the implementation plan recommends the minimal hardware and software changes needed. It is hoped that this paper will, at the very least, be a seed for future enhancements to the system.

6. Future Work

Upon successful implementation of perceptual narrowing, it will be easier to implement thin-slicing and its dark progeny: The Warren Harding factor. Preference of color—the color of the character's torch—could be treated as a source of Warren Harding errors that, under conditions of perceptual narrowing, would force the character to override all its rules and act only on the basis of its bias towards a particular color.

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