Visual Motion in a Railed Shooter Game: A Designer Study

David Milam[1], Magy Seif El-Nasr[2], Lyn Bartram1, Bardia Aghabeigi[2]

[1]School of Interactive Arts + Technology (SIAT), Simon Fraser University Surrey
250 -13450 102 Avenue, Surrey BC V3T 0A3 CANADA
{david_milam, lyn} @sfu.ca

[2]Northeastern University, Colleges of Computer and Information Sciences, and Arts, Media and Design,
Boston, MA, 02115 USA, 1 617.373.3982
{magy@neu.edu, aghabeigi.b@husky.neu.edu}

ABSTRACT

Visual design in games is a complex, but important, area of study, as it affects the player's experience. Previous games research applied knowledge in visual attention to understand visual designs, for instance through cues and lighting to influence players' behaviors and feelings. However, these approaches overlook how the visual design changes over time. In this paper, we focus on visual motion as an unexplored aspect of visual design, defined by a theory of visual perception as features associated with game elements. In particular, we consider the speed, size, and density of game elements in motion. Towards this goal, we developed a simple railed shooter game with a tool that allowed 8 expert game designers to manipulate perceptual features over time. Based on analysis of results collected through designers using this tool, as well as qualitative reviews, we present several perception-based design principles, stated as formulae of intended perceptual effects.

Categories and Subject Descriptors

H5.m. Information interfaces and presentation (e.g., HCI), K.8.0 Games

General Terms

Human Factors; Design; Measurement.

Keywords

Game design, visual design, visual perception

1. INTRODUCTION

Video games feature graphically rich environments that often rely on players' ability to perceive and attend to certain elements, while ignoring others in the game. One fundamental role of game design is to compose elements in such a way that clearly communicates the game goals to players. However, games are also entertaining precisely because they intentionally diminish the visibility of important elements and add irrelevant details, as a means to create variety or increase challenge. These examples illustrate why game design is a craft [1]. The art of composing a visual scene, which we will call visual design, is an important area to study as it influences the player's interaction in the game, but at the same time it is also complex due to the aesthetic nature of the craft.

Game designers often rely on intuition when discussing the visual design, often in the form of post mortems [7, 15]. Many game usability practitioners documented heuristics, or rules of thumb to support design [4, 13, 22]. Heuristics are important as they can prevent undesirable breakdowns [16] in players' performance. Breakdowns occur when players misperceive the environment, which causes a failed action, strategy, or incorrect decision. For example, game approachability principles [4] offered a checklist to improve the design through positive reinforcement, allowing practice to scaffold skills, and clear communication of goals. Given such discussion, few mentioned the manipulation of low-level perceptual features in reference to relevant theories of visual perception or attention, or took a design research approach to address this topic [14].

Theories of perception and attention are documented, and well known examples in include saliency [23], guided search [25]. These theories are based on a variety of visual search tasks that manipulate bottom-up (stimuli driven) features, such as brightness, color, and motion, in relationship to top-down goals. One theory that we think is important in the composition of visual designs is the similarity theory [5], defined as the degree to which elements that share a common feature are perceptually similar. A visual search task decreases in efficiency and increases in reaction time as non-targets become similar in appearance to targets, and as the degree of dissimilarity between non-targets increases (in other words, as the non-targets become increasingly different from each other).

Visual motion as a perceptual channel is constantly used in games, however is not well understood. A handful of researchers investigated low level features in the areas of lighting design [12, 19] and cues supporting navigation [11, 17, 20]. To our knowledge, no one considered visual motion based on a theory of visual perception, except for our earlier work [9, 10]. Within the field of visual perception, there is much research on the expressive features of motion including *speed*, *shape*, *phase* (periodic motion), *flicker* (flashing), *smoothness*, and *direction* [3, 8]. For instance, many of these features are found to influence affective impressions, such as valence, comfort, urgency, and intensity [8].

The research goal for this paper investigates how game designers change low level features of visual motion. These design insights are defined as intended perceptual effects, and are a first step in a larger research effort to adapt features of motion based on a model of users' experiences. To address this goal, we built a tool that allows designers to manipulate the speed, size, and density of elements in motion, over the lifetime of an example game. For the sake of simplicity we chose a simple railed-shooter game (designed similar to games like *Virtual Cop* (Sega, 1994) and *Rez* (Sega, 2001). The game is called EMOS, which stands for *Expressive MOtion Shooter.* Our triangulation approach is data-driven; it relies on collecting quantitative data from designers manipulating visual motion features using the toolset and designers' qualitative remarks driving their selections. The research questions include:

1. In what way do designers change individual or a combination of features over time?
2. What insights, if any, can be drawn from an analysis of these trends?

The following sections outline the previous work, method, including recruitment, study design, qualitative and quantitative data collection and analysis. Results include formulae of designers' intended perceptual effects, restated as perception-based design principles. These results can be used as heuristics or inputs into adaptive or procedural games, for instance in dynamic difficulty adjustment.

2. PREVIOUS WORK

The games industry often discusses visual design, for instance cues embedded in the environment [15, 22], however perceptual features are often excluded. Smith [22] presented five principles in this effort, including visibility, affordance, consistent visual language, feedback, and conceptual modeling. The principles provide guidance on demand and communicate to players that they are on the wrong track. Rogers [15] applied urban planning principles to organize visual elements on screen, extensively through landmarks and paths, as a means to cue the player's navigation behavior. While insightful, these works do not address motion and are not based on a formal experiment.

Some games researchers investigated low level motion cues and their effects on players' navigation [2, 6, 24]. For instance, the direction of water flow was shown to have a strong influence on navigation behavior when all other elements are static. Further studies in visual attention [20] and navigation aids [17] found low level cues (color, brightness contrast, and texture) depend on the top-down goal. While these studies are empirical, they did not address how multiple features of motion change over time. Additional game researchers built tools to study visual designs with the goal to elicit users' emotions, promote design reflection or develop algorithms to adapt the designs. Seif El-Nasr's lighting engine [18] controlled color, brightness contrast and camera positioning on virtual characters in order to evoke emotion, however this work did not include a formal user study. Zupko [26] developed a lighting toolset and collected feedback though interviews with expert lighting designers. This approach supported design reflection but did not quantitatively evaluate designers' manipulations with the toolset. Finally, Smith [21] developed a 2D level design toolset embedded into a game, that allowed a designer to edit the game difficulty based on global game parameters. This work did not include a formal evaluation with game designers.

3. METHOD

3.1 EMOS Game and Toolset

We developed a railed shooter genre game (EMOS) as a platform to test designers' visual design choices. This genre was selected as the camera is constrained, thus allowing a constant presentation of visual elements. The goal includes a fixed task to shoot moving targets as a means to advance through 15 levels. The trajectories of element motion are also fixed, and change in three 5-level blocks: *circular*, *expansion* (spawning in the screen-center and moving to the periphery), and *linear*. Two cut scenes, between blocks 1-2 and 2-3 allow players a brief rest in targeting. The game includes additional presentation constraints in order to investigate changing features of motion over time, such that element coloring is monochromatic, dynamic lighting and shadows are excluded, and only simple geometric shapes are used. The player avatar is also removed due to element occlusion, and replaced with a user-interface cursor.

Table 1. Features associated with game elements

Element		Name	Feature
Target (T)	T-B	Boss	speed, size, density
	T-M	Minion	speed, size, density
Non-Target (NT)	NT-A	Ambient	speed, size, density
	NT-R	Ring	speed
	NT-E NT-S	Feedback Explosion Feedback Sparks	size

As shown in Table 1, the toolset allows 11 instances of speed, size, and density features to be manipulated, in association with 6 game elements. Two of the game elements are *targets*, defined as boss targets (T-B) and minion targets (T-M), and the remaining four elements are *non-targets*, defined as ambient (NT-A), ring (NT-R), visual feedback sparks (NT-S), and explosions (NT-E). All features are independently adjustable in the toolset. Furthermore, boss, minion, and ambient non-target elements always move along the same trajectory in each 5-level block. Speed is the only feature associated with the non-target wireframe ring elements. Size is the only feature associated with the non-target visual feedback explosion and spark elements. Screenshots of how elements change using the toolset are shown in Figure 1. The toolset interface is shown in Figure 2.

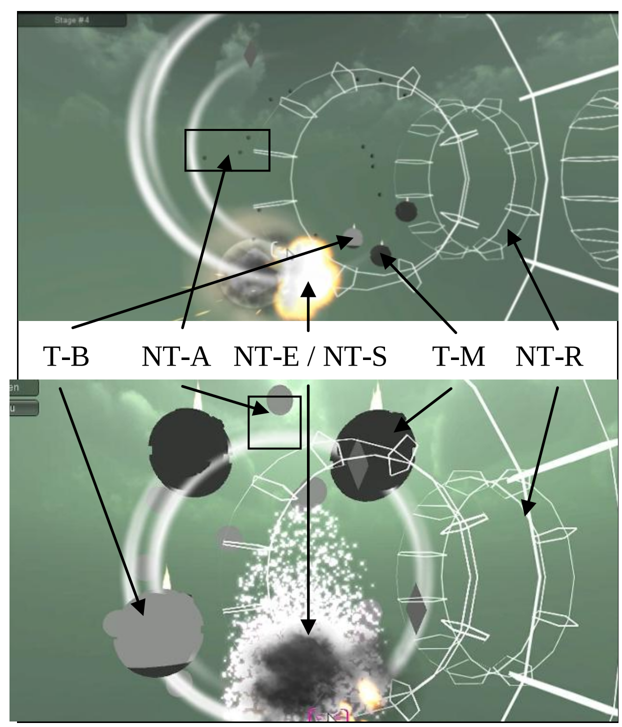

Figure 1. Adapting the visual hierarchy of game elements

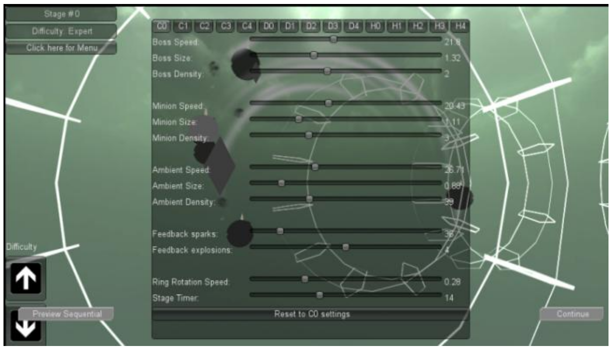

Figure 2. Screenshot of toolset user interface

3.2 Recruitment and Study Design

A total of 8 game design experts submitted encodings using the EMOS toolset. Experts were recruited through a network of game user researchers and interacted via an online version of the toolset. Table 2 includes the title and years of experience for each expert. It is important to note that the title and role of a designer is unique in each company and that a variety of roles contribute to the overall design. The background of experts therefore represent a broad range of design, and include art direction, programming, technical design, and visual effects. The researcher screened each designer to make sure each had published at least one game online. ID 8 was compensated given a background in psychology, usability, and design.

The protocol with experts took approximately one hour. Their goal was to manipulate features over time to produce 2 games: one suitable for a novice and the other for an expert player. At any point during this process, designers can hide the toolset, and switch to a play mode of the game. This mode allows designers to test and iterate their designs.

ID	Title	Experience
01	Associate Artist	5
02	Programmer	1
03	Technical Design	3
04	Technical Artist	10
05	Game Design	10
06	Visual Effects Producer	20
07	UX/ Game Design	17
08	Animator	5

Table 2. Designer title, background, and experience (years)

3.3 Data Collection and Analysis

Selections are saved and returned to the researcher. Each data file contains 165 data points (11 variables as changeable features across 15 levels). Designers did not change each feature in each level, so the submission includes default values for all untouched features. The data collected was organized in two ways:

1. *15 Level Analysis* that constitute one complete game submission.
2. 30 *Level Analysis* that combines two complete games. This analysis is necessary since designers did not change all features within one game submission.

The data collected from each designer is merged into a single data set. We then analyzed the data using a between subject bivariate correlation analysis. This procedure evaluates the change in features over time for all designers and produces two outputs: Pearson's correlation coefficient and significance result of the strength of the relationship. Pearson's coefficient is a measure of linear association between 2 features in the game. Positive coefficients identify a relationship between features that either increase or decrease as a group over time. A negative correlation identifies a relationship where one feature increases and the other decreases over time.

We also collected qualitative feedback with designers. This was done in 3 phases. Phase 1 is at the time of data submission, phase 2 is during a verification step, and phase 3 is an audio-recorded interview, 2-3 months later. In phase 1, experts provided e-mail responses to questions:

1. What are important trends in manipulating features?
2. What are limitations of the toolset?

For phase 2, designers were asked to verify their designs in a follow-up e-mail conversation consisting of a one page visualization summary of each designer's selections. The visualization consists of 11 line charts tracing the value of each feature per level in both games. All designers verified the accuracy of their selections based on the summary. Any qualitative feedback collected in this phase is included in the content analysis.

Phase 3 consisted of a structured interview where designers were asked to consider implications of the manipulation of features on the player's experience. The researcher took notes during this conversation that addressed question 1 or 2. Post interview, these parts of the conversation were reviewed again and relevant quotes extracted.

Qualitative data collected in phases 1-3 went through textual and inter-rater agreement analysis for seven designers. ID 6 is excluded since this ID only verified selections without additional qualitative remarks. This analysis identified important phrases in the conversation with designers along 2 major themes, in association with changing *individual* features or *multiple combinations* of features in association with specific game elements. Cohen's kappa statistic is used as a measure of inter-rater reliability for a total of 205 phrases found. Results found almost perfect agreement in these themes (kappa = .856). Open ended feedback regarding the limitations of the study, phase 2 question 2, are included in the limitations section.

4. RESULTS

4.1 Effect of Individual Motion Features

Designers discussed the visual design as an extension to the game design. All designers articulated the need for clearly visible targets since EMOS is a target shooting game, among non-targets that could easily be ignored. ID7 succinctly described this relationship as a mental decision making process, that "players have to identify and distinguish between target and non-target elements". For ID 7 this required "focusing more" on targets and "working harder" to maintain this focus as distractions increase over time. Distinguishing between elements is really *two* visual tasks that occur in parallel, first is to visually track and shoot at the boss or minion targets as these are linked to the level advancement or point acquisition goals, referred to as *targeting*, while the second task is to *ignore irrelevant distractions*. The ability for designers to conceptually distinguish and prioritize between element types often came before a more exhaustive discussion of perceptual features associated with elements, or how features change over time. For instance, ID 1 stated "once you know what these elements are in level 1 [referring to the target elements], these elements are all you look out for and the rest of the stuff is just stuff, they don't really matter anymore [referring to non-target irrelevant distractions to ignore]". Consistent with this reasoning, ID 3 agreed non-targets "may technically make things more difficult", however preferred that they appear "least distracting", "never change", and are "easy to ignore" as players would "want these constant". ID 2 did not want to "confuse players" with an additional challenge to ignore irrelevant non-targets as it "may hide important gameplay objects".

Given this conceptual grounding by designers, an increase or decrease in speed, size, and density features in question has multiple intended perceptual effects. These effects depend on whether features change in association with target or non-target elements, thereby influencing the ease of the targeting task (perceiving, moving and clicking the mouse) or ignoring distractions, respectively. In regard to the target elements, increasing speed or decreasing size makes targets *harder* to shoot and the level advancement goal therefore becomes harder, as discussed by seven designers. The opposite is also true, where decreasing target speed or increasing size makes the targeting task easier. The density feature is more complex as the rules associated with boss and minion target elements are different. Although increasing boss target density makes targeting easier, as there are more bosses to shoot on screen, the level advancement goal is *harder* as the rules dictate the same boss target must be shot *twice* in order to advance levels. In this case the level advancement goal is harder as density increases for boss targets since these elements are in continuous motion. This requires the player to visually track, precisely position the mouse cursor, and rapidly fire at the right time to successfully hit the boss targets. Six of the eight designers address increasing boss density as a method to increase difficulty in this way.

In regard to non-target elements, designers were unanimous in that increasing speed, size, or density makes ignoring distractions harder as this adds irrelevant noise into the scene. As a consequence of this, the targeting task also becomes harder. Two obvious examples of this by ID 1 and 7, is the possibility of "motion sickness" or "vertigo" in reference to the speed of non-target rings. Consistent with designers' views to balance difficulty, ID 1, 2, 3 and 5 preferred the least intrusive and infrequently changing features associated with ambient and visual feedback non-target elements. As stated previously, the intent is to make the non-targets easier to ignore. To this extent, these designers described the non-targets as "negligible", "ancillary", and should be "filtered out".

4.2 Change in Multiple Features

The correlation results are shown in Figure 3, which contain the 15 level analyses represented as several matrices. Each matrix represents a combination of only 2 features in relationship to the elements in the game that allow manipulation of that feature. For instance, the top 3 X 3 matrix is for density, and the 4 X 4 one below is for speed, since these features can be manipulated by 3 elements and 4 elements, respectively. Annotations for each cell in the matrix correspond to the element: boss (B) or minion (M) target, ambient (A), ring (R), explosion (E) and sparks (S) non-target elements. The blue/red color-coding of each matrix cell represents the positive or negative correlation coefficient. Dark blue/red signify high significance ($p < .01$) while light blue/red are significant ($p < .05$). White cells represent the same variable or no correlation.

The following is a summary of the 23 correlations found, organized by feature, based on a total of 141 individual correlations. Each result found includes the contributing IDs, in at least one case, in levels 1-30. General results identify the positive or negative correlation (+corr or –corr), along with elements and features in subscript. In order to investigate similarity (as outlined in the introduction) we use the delta measure, which describes the change between the two features in question. Positive correlations signify a constant delta where two features change together with no increasing or decreasing gap between their values. Negative correlations identify situations where one feature decreases while the other increases. A negative correlation either signifies a decreasing (↓Δ) delta (more similar) or an increasing (↑Δ) delta (more dissimilar).

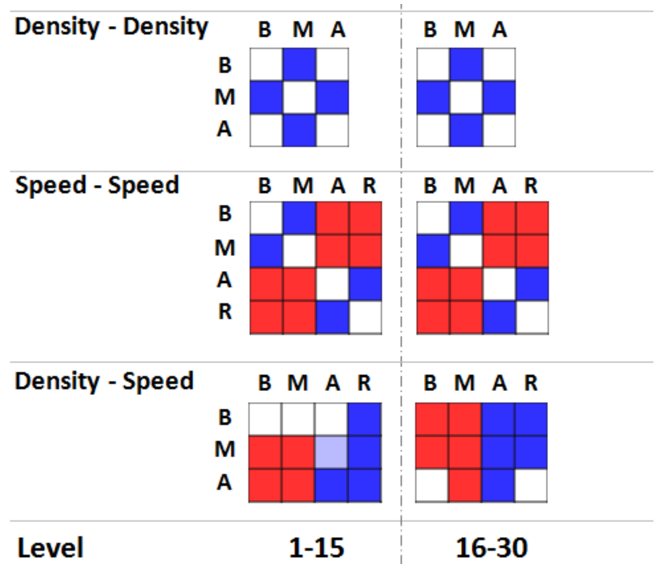

Figure 3. Correlation Matrix 1: 15 level analysis

4.3 Density – Density

1. **+Corr (T-B_{DEN}, T-M_{DEN}) constant Δ**
   Increasing for 4 IDs (1, 2, 4, and 5).

2. **+Corr (T-M_{DEN}, NT-A_{DEN}) constant Δ**
   Increasing for ID 5 only.

The first correlation asserts that as the target boss density increases, so does the target minion density. This means that the targets increase in density at the same time. As discussed by ID 2 and 4 in the previous section, this implicates how many targets the participant sees. Although, shooting targets is *easier* as the amount of targets increase, the level advancement goal is *harder* as the same boss must be shot twice. The second correlation is between the target minion density and the ambient non-target (NT-A) density. This result was found for ID 5 only, which was done to increase distraction.

4.4 Speed – Speed

3. **+Corr (T-B_{SPD}, T-M_{SPD}) constant Δ ↓**
   Decreasing for 7 of 8 IDs, except ID 8.
4. **+Corr (NT-A_{SPD}, NT-R_{SPD}) constant Δ ↑**
   Increasing for 2 IDs (7 and 8).
5. **-Corr (T-B_{SPD}, NT-A_{SPD}) ↓Δ**
   Decreasing delta for 3 IDs (2, 4, and 7).
6. **-Corr (T-B_{SPD}, NT-R_{SPD}) ↓Δ**
   Decreasing delta for 4 IDs (1, 4, 6, and 7).
7. **-Corr (T-M_{SPD}, NT-A_{SPD}) ↓Δ**
   Decreasing delta for 3 IDs (2, 4, and 7).
8. **-Corr (T-M_{SPD}, NT-R_{SPD}) ↓Δ**
   Decreasing delta for 5 IDs (1, 2, 4, 6, and 7).

The six correlations show increasing and decreasing speed over time. Although the correlation coefficients are both positive and colored blue in Figure 3, speed for boss and minion targets *decrease* over time, while speed for ambient and ring non-targets *increase* over time. In regard to the targets, a decrease in speed makes the level advancement and point acquisition goals easier. ID 4 discussed boss and minion target speed as a key feature in balancing the game difficulty. "I was able to properly identify targets, but had trouble hitting them [...] the speed of the enemies is a huge factor in the difficulty, not just for visual tracking but for response time in clicking on them. It's one thing to perceive the enemies, but another to have the skill in hand-eye coordination to target them accurately." At the same time, speed for ambient and ring non-targets increase, thereby increasing distraction. ID2 and 5 commented on speed shared by a combination of elements. ID 2 stated that "core difficulty comes from a mix of speed from enemies, ambience, and rings". ID 5 stated that "speed plays a massive factor in separating elements."

4.5 Size – Size

Due to the fact that changes in size are more pronounced in the 30 level analyses, we only show the 30-level analysis here. Figure 4 shows the results. The following are results for size in the 30 level analyses:

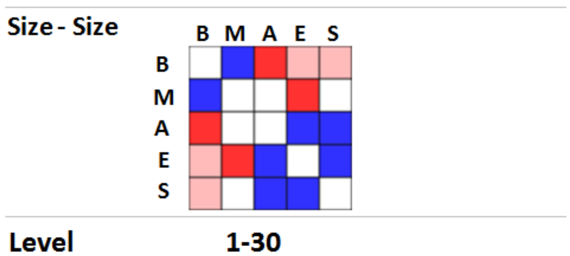

Figure 4. Correlation Matrix 2: 30 level analysis

9. **+Corr (T-B_{SZE}, T-M_{SZE}) constant Δ**
   Decreasing for 5 IDs (IDs 3-7).
10. **-Corr (T-B_{SZE}, NT-A_{SZE}) ↓Δ**
   Decreasing delta for 3 IDs (4, 6 and 8).
11. **-Corr (T-B_{SZE}, NT-E_{SZE}) ↓Δ**
   Decreasing delta for 3 IDs (4, 6 and 8).
12. **-Corr (T-B_{SZE}, NT-S_{SZE}) ↓Δ**
   Decreasing delta for 3 IDs (4, 6, and 8).
13. **-Corr (T-M_{SZE}, NT-E_{SZE}) ↓Δ**
   Decreasing delta for 4 IDs (3, 4, 6, and 8).
14. **+Corr (NT-A_{SZE}, NT-E_{SZE}) constant Δ**
   Increasing for 5 IDs (2, 4, 6, 7, and 8).
15. **+Corr (NT-A_{SZE}, NT-S_{SZE}) constant Δ**
   Increasing for 5 IDs (2, 4, 6, 7, and 8).
16. **+Corr (NT-E_{SZE}, NT-S_{SZE}) constant Δ**
   Increasing for 5 IDs (2, 4, 6, 7, and 8).

These eight correlations also show increasing and decreasing size over time. In the first correlation result, size for boss and minion targets are positively correlated and decrease over time, thereby making the targeting task and level advancement goal harder. Even though ID 1 and 2 did not manipulate target size, ID 1 stated that a "reduction in target size critically affects the player's success rate". ID2 stated "having smaller enemies gives a bit more umph to the challenge". In the last three correlation results, size for ambient, explosion, and spark non-targets are also positively correlated, and increase over time. The remaining 4 correlations are all negative correlations, thereby making the targeting task harder. Size for boss and minion targets decrease as size for ambient, explosion, and spark non-targets increase. ID 3 commented on this approach to increase difficulty in relationship to size for non-target explosions and sparks, "I didn't add distraction via the explosion/sparks to be a particularly "fair" (or interesting or whatever) way to increase difficulty. It feels cheap and not something I'd do in a game I'm personally designing and not something I'd generally advocate doing". In phase 3, designers ID 1, 4, and 7 agreed that increasing size for the non-target elements can be ignored to a certain extent, until they obscure the visibility of targets.

The eight negative correlations for speed and size with decreasing deltas (↓Δ in correlations 5-8 and 10-13) are examples of similarity. In other words, the same features become more similar in relationship to target and non-target elements, and therefore become more difficult to tell apart. Speed and size decrease for boss and minion target elements as the same features increase for non-target ambient and ring elements. In phase 3, ID 1, 4, and 7 agreed increasing distractions through similarity in size or speed are approaches to increase difficulty. In reference to size for target and ambient non-targets, ID 5 stated that "you are now forced to pay attention to them as your enemies are now hidden in the forest of huge distracting particles."

4.6 Density – Speed

Using this method of analysis, designers also manipulated different combinations of features at once, rather than the same features. One of the most frequent combinations is density and speed. While comparison of the deltas is not possible with different features, increasing or decreasing trends may still be observed.

17. **-Corr (T-B_{SPD}↓) (T-M_{DEN}↑)**: Speed decreases for boss targets and density increases for minion targets for 3 IDs (1, 2, and 6).
18. **-Corr (T-M_{SPD}↓) (T-M_{DEN}↑)**: Speed decreases and density increases for minion targets, for 3 IDs (1, 2, and 6).
19. **-Corr (T-M_{SPD}↓) (NT-A_{DEN}↑)**: Speed decreases for minion targets and density increases for ambient non-targets for 3 IDs (4, 6, and 7).
20. **+Corr (NT-A_{SPD}, T-M_{DEN}) ↑:** Speed and density increase for ambient non-targets and minion targets (ID 2).
21. **+Corr (NT-A_{SPD}, NT-A_{DEN}) ↑:** Speed and density increase for ambient non-targets for 2 IDs (6 and 7).
22. **+Corr (NT-R_{SPD}, T-M_{DEN}) ↑:** Speed and density increase for ring non-targets and minion targets for 6 IDs (ID 1-6).
23. **+Corr (NT-R_{SPD}, T-B_{DEN}) ↑:** Speed and density increase for ring non-targets and boss target density for 4 IDs (ID 1, 2, 4, and 5).

The seven correlations between speed and density show different effects with respect to the level advancement and point acquisition goals. In all cases, the net effect makes the level advancement goal *harder* as features associated with the minion target, or a combination of non-targets increase distraction. While this result is consistent with designers views that difficulty increases over time as this is characteristic of the genre, five designers (2, 3, 4, 5, and 8) *increase and decrease* difficulty with respect to density for boss or minion targets, and speed for ambient and ring non-targets. These *ramping difficulty* manipulations occur within the 5-level fixed trajectories of motion, in sync with the two cut scene rest-breaks, between blocks 1-2 and 2-3.

In phase 3, ID 4 addressed ramping difficulty as "a process designers are not aware they do", that is, a common approach in game design to "train novice players to become experts, as quickly as possible. So you make it easy in the beginning and ramp up the difficulty as quick as your players can handle". In phase 2 and 3, ID 7 expressed caution with this approach, and preferred only gradual and linear increases in difficulty as inexperienced players may perceive these levels as too difficult or distracting. "...they [designers] are thinking more about the game play and not the trajectory of the first time experience. […]. I would apply ramps after the first 5-10 minutes of play, so my selections were based on accessibility rather than regular game playtime. I do more predictable in the first 5 minutes of play, even for experts, so they can have success-then ramping can be applied for excitement." Later on ID 7 stated, "When the designers ramp things up the way they did like in yours, I was not surprised. That's typical because I think they are concerned more with the gameplay and less about the trajectory of the first time experience."

5. DISCUSSION

This study investigated intended effects surrounding 8 designers' manipulations of speed, size, and density features for elements in motion within the context of a game. The approach taken to uncover trends is novel in that results are based on designers' manipulations of specific features in association with target and non-target elements.

Designers discussed effects of individual motion features associated with these elements. In summary, any manipulation of features associated with targets influences the ease of the targeting task, while manipulations to features associated with non-targets influences the amount of distraction. Multiple opportunities were found to increase distraction, however, designers were careful in manipulating specific features that could easily be ignored or did not interfere with the visibility of targets.

Designers also discussed effects based on the change in multiple features. The correlation analysis found the strongest and most frequent manipulation of features over time. For instance, target speed decreased in order to make the targeting task *easier*, as noted by designers. This trend was counter-balanced in a variety of ways, for instance, by increasing target density or decreasing size, or increasing features associated with the non-target distractions, which made the level advancement goal harder. Four of 8 IDs, *increase and decrease* target density and non-target ring speed over time, with the intention to train players. ID 7 cautioned using this approach early in the game as a means to boost excitement, so that new players may become accustomed to the game.

A summary of designers intended effects are presented as perception-based principles, based from the manipulation of features, in association with targets or non-target elements.

5.1 Principle 1: Targeting Task

Targeting difficulty refers to engaging in the targeting task, using the control device to click on targets, in pursuit of the level advancement goal. The boss targeting task becomes *harder* (increasing difficulty **↑d)** as density and speed increase and size decrease, since bosses are in continuous motion and the game rules dictate that two bosses each require two shots in order advance to the next level. By the same rationale, the boss targeting task is easier as target density and speed decrease, and size increases.

- $\uparrow \mathbf{d} = (\uparrow \mathbf{T}_{DEN}, \uparrow \mathbf{T}_{SPD}, \downarrow \mathbf{T}_{SZE})$

5.2 Principle 2: Ignore Distractions

Non-target elements are distractions and interfere with targeting difficulty. Therefore any increase in features associated with non-targets makes them more difficult to ignore and reduces the target visibility. By the same rationale, ignoring distractions become easier when these features decrease.

- $\uparrow \mathbf{d} = (\uparrow \mathbf{NT}_{DEN}, \uparrow \mathbf{NT}_{SPD}, \uparrow \mathbf{NT}_{SZE})$

5.3 Principle 3: Element Differentiation

The user's ability to differentiate between target and non-target elements in the game has an impact on game difficulty. This is based on the 8 correlations found supporting stimuli similarity [5] for speed and size. We assume initially in the game that the target speed and size are faster and larger than the non-target speed and size. Given this assumption, two formulae outline the impacts of element differentiation on game difficulty. Difficulty increases in relationship to the level advancement goal when target and non-target speed or size become more similar (↓Δ), and therefore more difficult to differentiate.

- $\uparrow \mathbf{d} = \downarrow \Delta\ (\mathbf{T}_{SPD}, \mathbf{NT}_{SPD})$
- $\uparrow \mathbf{d} = \downarrow \Delta\ (\mathbf{T}_{SZE}, \mathbf{NT}_{SZE})$

This finding supports our intuition that similarity is present in designers' manipulations of features. However, as the theory also discussed, non-target dissimilarity was not found in the correlation analysis as these features are always positively correlated and increase together. Future investigation may consider the underlining feature values to determine non-target dissimilarity. This result is nevertheless novel in that a perceptual theory can be investigated within a game to understand the visual design.

6. LIMITATIONS

Limitations include the designers phase 1-3 comments regarding fixed game features, learning how to use the tool, and usability concerns. Fixed features of discussion include color, motion trajectory, and the rules For example, ID 4 states, "It's possible that even with a lot of visual noise, if the targets contrast enough with the overall environment, even a novice would be able to identify them correctly and without experiencing fatigue." Additionally, ID 2 relied on the "predictability of motion" when manipulating speed for a combination of target and non-target elements. ID 3 stated, "...the abstract quality of motion was one drawback, as the grouping of targets and distractions looked artificial and not like a typical casual game."

Designers had to learn the tool and work within its constraints to formulate selections. The structure and constraints of the game had already been planned before they interacted with the toolset, and designers were not accustomed to producing a game in this way. While experimental games are common in games research, they are less common in industry. The perception based motivation embedded into an experimental game was a foreign concept to communicate initially. For example, ID 5, stated, "I had difficulty creating a sense of the space… I couldn't figure out the logic of the space. Ordering of sequence is unusual but still workable." ID 4 suggested changing the targeting rules of the game to assist the player as challenge increases. Designers are accustomed to iteration across all aspects of the game design.

Along with learning the tool, ID 1, 4, and 7 commented on usability issues in regard to the manipulation of features. They suggested a control panel to visualize features changing across all 15 levels in one display, instead of sliders on a per level basis.

Even with the copy feature, this method of manipulation became repetitive for designers since each difficulty setting is sampled 15 times for 11 features. Designers commented that they needed to remember settings and switch back and forth between difficulty settings while modifying selections. The visualization solution for instance could make the general trends found more obvious to designers.

7. CONCLUSION and FUTURE WORK

This study investigated eight designers' manipulations of perceptual features *speed*, *size*, and *density* for elements in motion, within the EMOS experimental railed-shooter game. Only features changed over time, in association with 2 targets and 4-non-target elements. Many intended effects were found based on designers' verified selections using the EMOS toolset, qualitative expert review, and correlation analysis between combinations of features. Results found designers manipulate individual and combinations of features with different intended effects. These intended effects were then synthesized into three perception-based principles, including *targeting task*, *ignore distractions*, and *element differentiation*. The latter principle is consistent with the similarity theory of visual attention as a means to diminish task performance, and suggests additional theories in perception and attention may be studied within the context of a game, particularly in topics concerning the visual design. Validation of these principles is an area of future work in addition to modeling features in adaptive or procedural games, for instance to adjust difficulty.

8. ACKNOWLEDGEMENTS

Thanks to the game designers and Dinara Moura for coding support. This research is funded is by the Natural Sciences and Engineering Research Council of Canada.

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