HUMAN FACTOR AND ERGONOMIC CONSIDERATIONS AND IMPROVEMENTS FOR A TABLE-FREE CARD GAME PRODUCT

by

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ABSTRACT

The purpose of this project is to design a table-free Yu-Gi-Oh! Card Game product that will make the transition of said game from table to user more fluid and intuitive, improving on past designs in the process. Despite there currently being many similar products in the market, there has yet been one that adequately fulfills game requirements and comfortably adapts to the range of players associated with the game. Taking ergonomic and human factor considerations into account during the development of the design, a prototype was created as part of this project that was subsequently tested against a past product to see if improvement in game tasks were produced. The data collected yielded statistically significant results in terms of the placement of cards into Spell/Trap Zone areas of the device. Surveys conducted displayed by and large an inclination towards the new prototype’s design features and use. Despite the need for manufacturing cost estimates, future enthusiasts are recommended to reduce the weight of future designs before mass production.
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INTRODUCTION

While the Yu-Gi-Oh! Card Game has been enjoyed by players of all ages for over 10 years, due to the association of the Japanese manga books and anime series’, these players can only hope to play the game in the fast-paced and table-free environment shown in the accompanying media. Despite a major factor being the lack of holographic projectors, attempts at making the game portable have succeeded solely in their novelty resemblance to the corresponding shows that spawned them, with little or no practicality in their application to the game rules and requirements, leaving serious players stranded on tabletops. The demand for a gaming device that is both assessable and compatible with the game it is intended for is still yet to be actualized. With this in mind, this project’s goal is to design a card-holding apparatus (known in related media as a Duel Disk) for the Yu-Gi-Oh! card game that will allow players to engage each other without the use of tables.

Due to the extensive popularity of the game in countries all over the world, this concept is not by any means a new one. A range of products – or rather, toys – have been developed in an effort to gain the business held by this particular pool of game playing consumers. Unfortunately, they alienate players with their casual attention to detail and poorly designed features that at their best still fall short of incorporating fundamental game essentials. These products also isolate older gamers by pandering to a younger niche, becoming impossible to wear because of smaller wearer specifications. Disparaging as these results have been, the product at this project’s focus hopes to correct these past errors using meticulous yet inclusive design considerations and effective but creative design methods.
To accommodate the prominent requirements of this project, several technical approaches will be used. First, since the product in question will be in contact with the player’s forearm, data must be collected to create an attachment that will encompass a considerable player population. Next, to reduce the possible confusion caused in this new gaming environment, the layout of the product must incorporate game expectations the player will recognize as well as human factor techniques to make it an effortless experience. Finally, an experiment must be designed to compare its success in improving on current products that are on the market.

The following report, in order to complete these many tasks, will provide and document: a substantial game/product background – supplemented with project relevant literature reviews; the design and selection of a Duel Disk design, ergonomically fitted for its intended users; creation of a working product prototype, suitable for use in the experimental phase of the project; and finally, a comparative experiment determining whether the newly designed product successfully exceeds previous products’ utilization of game/player requirements, in addition to meeting them.
PROJECT BACKGROUND AND LIT REVIEW

In 1996, Kazuki Takahashi, a Japanese manga (graphic novel) artist published his work, entitled Yu-Gi-Oh!, in Weekly Shonen Jump magazine, which showcases a variety of different titles aimed at young male readers. Centered around a boy named Yugi who upon solving an ancient Egyptian puzzle becomes infused with the soul of a mysterious, game playing spirit, the story pitted the protagonist (and his skillful occupant) against many rivals and villains in a spectrum of different games, at least that was the initial intent. After introducing a card game (called Magic and Wizards, later named Duel Monsters) in a couple of chapters, Shueisha, the magazine’s publisher, received tons of fan mail asking about the new game. This caused Takahashi to expound on the game in further issues, eventually enveloping the entire series. As if catching fire, the story and game jumped into a spectrum of mediums, spawning five different anime series’, five different manga series’, three (two of which are feature length) movies and two trading card games. Though the first incarnation of the game, produced by Bandai, is now discontinued, the second, made by Konami, has lasted for over a decade and continues to release new booster sets and cards several times a year.

As said before, this game has also been the focus of many products. In addition to reviewing the attributes and flaws of these products, the forthcoming literature reviews will highlight the many sources used in obtaining the requirements of the design, design considerations/methods, and experimental procedures utilized in this project. These include other case studies that relate to ergonomics and human factors issues. The topics discussed will come into play during the creation of the product as well as the final
design selection/evaluation. Relevant information regarding each source is mentioned as it pertains to this project; any supplemental data is given solely for contextual reasons.

Source 1:


As this project deals heavily on the understanding of the Yu-Gi-Oh! card game, it is vital that the rules and requirements of the game itself are thoroughly noted. The rulebook is the prime source for such information.

Other than game mechanics and card types, necessities for playing the game are also mentioned. Figure 1 below shows the game mat used in most – usually beginner – games, or duels as they are commonly called. Counting the number of spaces on the mat, it is seen that 14 areas are set aside for various cards and game actions. For example, Area 3 on Figure 1 shows where cards are piled once they have been played. This area is referred to as ‘the Graveyard’. Areas 2 & 3 display where Monster and Spell/Trap cards are placed during normal game phases, respectively. While the game mat isn’t officially required for a duel, it serves as a guide on how a game is setup and where cards are placed. Lastly, in addition to these areas, there is another area mentioned in the rulebook, known as the ‘Removed From Play Zone’. This area is similar to the Graveyard, however, is not given an area on the game mat. These areas encapsulate all the field requirements of a duel.
The understanding of the duel field is probably the first thing needed to play the game. The next would obviously be the cards themselves. A collection of cards that a player uses during a duel is called a Deck. To legally play, the maximum amount of cards a player can have in their deck is 60 (this number was originally unlimited) and the minimum amount of cards is 40. This deck is further defined as the Main Deck, as it is the only deck mandatory to engage in a legitimate duel. The other two decks, the Side and Extra Deck, are optional and each allowed up to 15 cards for use. These options, which are available to players under normal circumstances, must also be available in a non-tabletop environment, specifically the kind produced by this project’s desired creation.

Lastly, the rulebook mentions items sometimes used in duels as well as items that may be useful during one. Several cards in the game require the use of dice, coins, and counters. A counter is an item that simply keeps count of a value used by a card. Dice and coins are employed when a random value is needed; most often, physical dice and coins are used, but digital versions included in calculators are also allowed. Speaking of which, calculators are highly recommended due to the fact that each player starts with 8000 Life Points (indicator of player vitality – once a player’s Life Points reach 0, that player loses)
that gradually are reduced during the course of a duel through various actions. Though needing more materials, pencil and paper are also handy in lieu of a calculator.

These designations, tools and essentials are known and utilized by all players of the game and as such should be considered during the design portion of the project.

Source 2:


This reference provides some general information on the concept of a duel disk, the card-holding device used to play the Yu-Gi-Oh! card game in every incarnation of its eponymous franchise.

According to the accompanying mythos, the duel disk was created by Seto Kaiba, a rival character in the series, to gain an advantage against another villain character, Maximillion Pegasus, who used conventional – albeit gigantic and hologram projecting – tabletop environments during the first season of the second series. Although the circumstances depicted on the anime series are a bit more dramatic, it can be seen that this device does make dueling a lot more portable. Because of this, duels can be engaged practically anywhere two people can stand apart, facing each other.

Many variations of the device emerged as the television show (and its many spin-offs) progressed. Despite its evolution, features of the duel disk remained constant. These main features include: life point counter, deck slot, graveyard slot, and the main disk, which holds the majority of Monster/Spell/Trap cards. Figure 2 shows three of the duel disks showcased by their respective series protagonist. The designs, though some more
streamlined than other, all show similarities. As the popularity of the show and game grew, it became profitable for real companies to capitalize on the craze.

**Figure 2: Many versions of the duel disk exist – often accompanying a new character.**

Several toys were developed. The toy company, Mattel, has released to date four different duel disks. Officially dubbed, ‘Duel Disk Launchers’, the toys had the novelty of sharing the appearance of their cartoon counterparts, which pleased fans of the show who were solely interested in them as costume accessories. Unfortunately, they were less than effective for serious game players who desired a useful gaming apparatus. An Asian company created the ‘Fight Disc for Card Games’ which was slightly more game-friendly but also lost the visual appeal of the Mattel produced disks. Both the Asian and Mattel disks have been discontinued – practically only available on buying websites such as Ebay. Recently, in 2011, Konami has released a duel disk that improves on old designs as well as adds new features, such as Side and Extra Deck holding areas.

While the specific features and flaws seen in some of these versions will be discussed in greater detail by the next source, the thing to take away from this source is the prevalence that the duel disk has had on the Yu-Gi-Oh! franchise and community. Its
features have become so ingrained that they will most certainly be expected in future designs of the product by its consumers.

Source 3:


This source gives more information on similar products currently on the market that share several qualitative attributes with this project’s consequential product. Because this source is from a site created by fans of the show and players of the game, it is assumed that the information contained is reliable (though this assumption is reluctant as these particular product evaluations were not found elsewhere).

**Figure 3: Current duel disks created by Mattel and Konami.**

Earlier, it was mentioned that Mattel and Konami collectively made five different duel disks. Several of their characteristics are listed below as well as how effective they incorporate game requirements:
**Mattel’s Duel Disk Launcher** (Seen on the top left of Figure 3)
- Similar in appearance to the Battle City duel disk seen in the second Yu-Gi-Oh! series
- Not compatible with card protectors
- Graveyard and Deck areas can only hold a limited amount of cards
- Life Point counter can only go up to 9990

**Mattel’s Chaos Duel Disk** (Seen on the top center of Figure 3)
- Similar in appearance to the villain duel disk seen in the second Yu-Gi-Oh! series
- Same flaws seen in the Duel Disk Launcher

**Mattel’s Academy Duel Disk** (Seen on the top right of Figure 3)
- Similar in appearance to the Duel Academy duel disk seen in the Yu-Gi-Oh! GX series
- Though now compatible with card protectors, still has Graveyard/Deck limitations
- Unlike all past disks, Spell/Trap slots are in the same orientation seen in the series
- Velcro straps are only one size

**Mattel’s Yusei Duel Disk** (Seen on the bottom left of Figure 3)
- Similar in appearance to the hybrid duel disk seen in the Yu-Gi-Oh! 5D’s series
- Clips for holding Monster cards down
- Spell/Trap slots similar to Duel Disk Launcher
- Same flaws seen in the Academy Duel Disk

**Konami’s 2010 Yusei Duel Disk** (Seen on the bottom right of Figure 3)
- A revision of the previous Yusei Duel Disk, without Monster card clips
- Unlike all previous disks, Removed From Play and Extra Deck areas added

As newer versions of the duel disk were released, improvements and design alterations were made to keep it updated with the current anime series as well as consumer wants. Notice that after Chaos Duel Disk, all subsequent disks became compatible with card protectors (card sleeves, which most professional duelists use).

Regardless, issues with the amount of cards permitted in the Graveyard and Deck areas have always plagued these products. And with cards that have the ability to raise Life
Points beyond 9990, the Life Point counter was limited at first. However, both Yusei Duel Disks added a digit to this counter, encompassing most game situations. Overall, there is still room for improvement.

Finally, when designing the product for this project, recurring features seen in these duel disks should be considered for future revision, and flaws should be noted for enhancement.

**Source 4:**


The following study was conducted among three computer input devices: a mouse, a trackpad, and a newly designed input device. During the evaluation, it was shown that the new device was not as successfully utilized as the other more conventional products, but in the end, this may have been caused by a few factors that may or may not have been in the designers control. These factors of failure are discussed below and hopefully avoided during this project’s design phase.

**Figure 4: Input device tested during the product comparison study.**
The new input device, shown above in Figure 4, is an apparatus worn on the hand, with motion controls located on the outer most digits, controlled by the thumb. This device is comparable to this project’s in that they both are not restricted by a tabletop environment. In the case of this input device, this alleviated pressure on the outer most extremities during computer operation. In addition, during usage of the product, the users were seen to adapt more ergonomic postures; this could account for the loading reductions seen as well. Despite these obvious positives, when looking at the results of the study, it was shown that the other two devices performed the given tasks much better than the newly developed one. Upon experimentation completion, subjects were asked to give an account of what they believed to be the main reasons for the products failure. They are as follows:

- The use of the thumb for control was awkward due to its dual nature as a stabilizer and clicker
- The unfamiliarity with the new device’s controls made its usability perceptually more difficult
- The complexity of operation seen in the device reduced performance

These possible flaws could have been avoided had the designers of the product/experiment: employed use of a more agile digit for input control, had more time to introduce the user to the device, and made the controls less complex during usage.

Though it may have been a utilization failure, this product shows room for development and acts as a guide that this project will use to avoid similar designer caused consequences.
Source 5:


This next source was hardly helpful as far as specific design considerations is concerned, but on the other hand showed the possibilities available after such design improvements are added to an enriched product.

This article contests that crutch design, while seen in a few different forms, has not changed much in overall design, forcing users to expend more energy and leading them to possible injuries in the process because of the unusual positions their arms/hands must take on to use such crutches. To reduce these injuries, such as Repetitive Motion Injuries (RMI) and Cumulative Trauma Disorder (CTD), innovators designed a crutch that used electric impulses during use to massage the wearer’s hands. This electric power was also accessible to the user for personal items such as cell phones, music players and other small electrical devices.

This extra feature that was employed after the initial goal of the innovation was achieved is very important to consider during this project. While, functionally, the aim is make improvements, weaving in little rewards like the one shown in this article, could be used to enhance consumer satisfaction.
Source 6:


This article also presents us with a product comparison study. This time ergonomically enhanced scissors to be used by hairdressers is the device under scrutiny. The success conditions seen here should be noted.

RMI and Carpal Tunnel Syndrome (CTS) plague extensive users of conventional scissors such as hairdressers who must employ their aid on a continual work basis. Because of this, the Ergonomic Tool Design scissors, or ETD scissors for short, were created to hopefully reduce said injuries. During the study, they went head to head with normal scissors of the industry. Compared to its average competition, the ETD scissors were seen to: allow for higher grip strength, require less bending of the wrist, increase neutral wrist time, provide for a straighter cut, and increase the comfort level of the users.

After use of both scissors, comfort ballots were taken at the end of every experimental period (which consisted of a normal 8-hour work day) to access their effectiveness. As previously mentioned, the feedback was incredibly positive. Comfort level naturally being a big desire for the user, wants must be taken into account during design of the user restraint portion of this project because if the wearer doesn’t like wearing the device, they would most likely not want to use it and the longer they can comfortably use the device, the longer they can enjoy the game.
Source 7:


With discomfort in mind, this next source studied the effects of discomfort in relation to various forearm and hand positions. The forearm being the area of the body that will be in constant contact with this project’s invention, this study is important in observing where the most discomfort lies, so that, when designing the duel disk, the position of least discomfort is employed during common practice.

The three factors under study were hand up/down and side-to-side bending as well as forearm rotation. There were many different interactions shown in there combinations of these factors. However, the most critical combination in question is the one which produced the lowest level of discomfort (measured by a Raw Discomfort Score, RDS). Although seemingly obvious, the combination that had the desired output was where no rotation, or bending of any kind was seen. That is to say, when the arm and hand were at straight neutral positions, the level of discomfort was the smallest. On a smaller note, rotation of the forearm in any of these configurations increased the RDS as well.

As stated before, the forearm is where the duel disk will be fixed onto the players, as seen in previous products. When creating this gripping device, duelists should be able to wear it with minimal to no rotation of the forearm. This rotation is a possibility as past devices are shown to not be symmetrical – allowing for rotation of the disk and forcing the user to rotate their forearm during duels. This can also be caused if restraints to the
disk slip due to not being strapped on tightly enough. Hopefully, a balanced design of the disk or a less slip-prone restraint will solve this issue.

Source 8:


The following study was used to observe alternative methods for designing a product. Though the study dealt with use of highly technical instruments such as Virtual Reality (VR), the goal for less expensive research methods and faster results is the relevant issue that will be looked at.

Due to the fact that the interface of a product highly influences customer satisfactions, and in turn, product success, allowing designers to get into the minds of the users is one of the keys to creating a profitable design. Participatory Design, though advantageous because of its concern for user attitudes in the design process, can be an expensive approach, mainly because of two things: physical mockups are required because user expectations mimic those of current products requiring actual devices for evaluations and the gap of technical knowledge between the user and designer are cumbersome to bridge during experimentation.

Virtual prototypes were designed to reduce these costs. As actually material was no longer necessary, designers could fit product specifications with those of the user. This also decreased the time it took for said products to reach the market because the swift completion of the design phases for these items. Although computer processing power on par with those used in this study is not an option for this project, less
consumptive methods for designing the product must be employed both because of financial and time constraints. If this is achieved, experimentation and results can be assessed more thoroughly, leaving time for possible design revisions.

Source 9:


This article mainly discusses a designing tool called SILK (short for Sketching Interfaces Like Krazy) and its impact on allowing for more human-friendly design interfaces. Though interesting, its use in this project is its mention of the importance of sketching in the design process.

Sketching is a vital tool for designers for many reasons. Due to the perceived informality of the interaction, creative designs can be achieved because of the relaxed environment. The unrestrictive and uncertain bounds allowed for with a blank design space makes exploration of ideas easier than when rules are employed, as with drafting programs and tools. In many cases, it was seen that less ideas emerged as a result of using such tools. Designers would refine an initial idea with the extensive options available to them with these programs, while drafters using sketches could produce several various designs, since refining of these ideas was obviously saved for later stages in the process.

Because this project deals heavily on the design of a product, this unbidden form of creation will most definitely come into play during various stages of prototype design, assumingly developing a spectrum of options to choose from.
Hoping to broaden the design methods employed in this project even further, this next source describes many techniques utilized in the design process. These potential modes of thinking may serve useful when conceptualizing possible ideas for this project’s duel disk.

Novel concept ideas are often described as “creative leaps” with seemingly inexplicable origins. Being such, they are difficult to artificially create in a design setting. Fortunately, upon review of the design process for a bicycle accessory that would restrain a backpack, several vital methods emerged and were noted. They are seen below in Figure 5. A short synopsis of each is given beside the graphic.

**Figure 5: The various design techniques employed in most design environments.**

- **Combination:** synthesizing features from existing designs into a new configuration
- **Mutation:** modifying the form of some particular feature
- **Analogy:** abstracting behavioral features of an idea onto an existing design
First Principals: identifies core requirements and then develops them into a design

While mutation will be saved for later stages of the process due to its refining nature, combination, analogy and first principals will probably be employed at the start of the design phase. Undoubtedly, all these techniques will be considered and utilized by this project’s conclusion.

Source 11:

*Evaluation of human factors in interface design in main control rooms. Hwang, Sheue; Liang, Sheau-Farn Max; Liu, Tzu-Yi Yeh; Chen, Po-Yi; Chuang, Chang-Fu. ‘Nuclear Engineering and Design’ Volume 239. 2009. Pages 3069-3075.*

This final reference describes the possible consequences of using an improved system. While superior forms of a system are preferred, this human factors study conveys the need for evaluation upon the implementation of such environmental enhancements.

As digital systems replace older analog ones, nuclear power plants must also conform to the times and update their measuring systems. Possibly being too hasty, a performance evaluation was performed to look for any unknown recoils of such integration, so that safety and efficiency of the system remained intact. After performing a series of routine tasks, the evaluators noticed several problems. The top three problems seen in the system were:

- Water level values on the instruments were slightly inaccurate, causing distrust by operators
- The decimal point on a digital display was too small, often producing invalid readings
- The alarm errors were confusing due to the abbreviations utilized for common declarations
The results of these experiments show that despite perceived upgrades to the system in question, other flaws were taken for granted and surfaced during common usage. When designing a new duel disk, the possibility for this to occur must be reconciled somehow. For that reason, when comparing products during the experimental phase of the project, the experimental coordinator must allow room for similar evaluations as those shown in this study. Surveys of what is right and wrong with each product should be developed. Experimenters using this data can then rectify any rising issues seen in the new product. This is form of evaluation is vital to obtaining an optimal design prototype for this project.

In conclusion, the studies and techniques observed and reviewed in this section will aid in the development, creation and experimentation of the duel disk this project hopes to produce. Design being a fundamental factor in the success of any project, the stress of proper, effective, and creative methods was highly critical to the research done here; though it will only strengthen the outcome of the product, experimental procedures may have received little attention due to the extensive background done on design. Using this as an advantage, said experiments should be meticulously developed using these design methods to account for specific citations on the topic.
DESIGN: CREATING THE PROTOTYPE

This section will outline the methods, reasoning, and processes used to design, create, and assemble a prototype aligned with the objectives discussed earlier as well as one that is capable of withstanding a repetitive comparative experiment against a previously released product. This section will cover the game and player requirements considered in development, the importance of user compatibility/comfort and how it changed the player attachment design, and finally, the final design configuration created as well as how the final design was chosen and put together using multiple techniques.

Game Requirements

Upon review of the Yu-Gi-Oh! Official Rulebook, the total card requirements utilized in the various zones during official game play is directly or indirectly defined. These zones, their purpose, frequency of use and their maximum card conditions are listed below:

- **Main Deck Zone** – The mandatory Main Deck is placed here. As it contains the majority of cards used during a duel, it is used usually every turn. Its maximum capacity is 60 cards.
- **Extra Deck Zone** – The optional Extra Deck is place here if used. The Monster Cards that make up this deck are only used if specially called upon during average games, though due to their various special abilities and greater strengths, it is almost always used, especially during tournament games. The Extra Deck can have no more than 15 cards.
- **Monster Card Zone** – Monster Cards are placed here (in either 2 positions) once put into play. Monster Cards are usually about one half of a player’s Main Deck, so these zones are highly used. While each of the five zones that make up the Monster Card Zone once only allowed for one card per zone, a new game mechanic that involves staking cards on top of each other has increased this maximum card occupancy to six.
- **Spell/Trap Card Zone** – Spell and Trap Cards are put here during game play. Since they consist of the remainder of cards in the Main Deck, these zones are also used often. Each of the five zones that make up this zone can have only one card at any time.

- **Field Spell Card Zone** – Field Spell Cards, a specific type of Spell Card, are placed here when played. Though mildly used during duels, this zone is occupied until the card occupying it is removed by a player. Only one card is allowed in this zone at once.

- **Graveyard Zone** – Most cards that have been either destroyed/discarded/activated are normally placed here. The conflicting nature of most duels keeps this zone frequently in use. This zone potentially can have all the cards used in a duel from both the Main and Extra Decks, making its maximum capacity 75 cards.

- **Removed From Play Zone** – Special cards that specify that a card is ‘removed from play’ are placed here as an alternative to the Graveyard Zone. Because of the terminal nature of cards that are placed in this zone, most players opt to include cards in their decks that include this mechanic, causing this zone’s utilization to range from high to non-existent depending on the type of strategy used by both players. Due to this zone’s dichotomy with the Graveyard Zone, its maximum capacity is also potentially 75 cards.

In addition to the requirements listed above, there are a few other considerations that, while not having their own particular zone for placement, will be mentioned below, as their occurrence in game play makes their incorporation into the design essential. These supplements are described below:

- **Player’s Hand** – During table-top game play, both hands are available for shuffling decks/cards when the time calls for it. At those times, a player’s hand (normally held by one hand during games) is usually placed on the table, however, since this design seeks to remove the table from the player to increase
versatility, this option is no longer available. As a response to this table-less environment, a clip for holding a player’s hand should be integrated to alleviate the need for holding the cards with one hand. The number of cards that can be in a player’s hand upon the end of their turn is six cards (the need to hold more cards is rare as there is a minute amount of cards/strategies that lets a player exceed this limit, so six is quantity this design should satisfy).

- **Side Deck** – Despite a duel being the faster format for casual games, matches are what occupy tournament and long duel sessions. A match is a series of duels that decides which player is at a higher level of gaming (the winner usually advances to a subsequent level of tournament play or player recognition). The number of duels in a match is either two or three; the first player to win two duels ends and wins the match. Because player techniques and deck types can often result in unbalanced and one-sided games, the Side Deck is an option that players can use to counter these complications. During a match, after the end and before the start of a duel, a player can swap an equal number of cards from their Side Deck to Main Deck. Once swapping is finished, both decks must have the same number of cards they began the match with. The chance for players to retaliate to an opponent’s winning strategy is critical for duelists, especially during high stakes games. As such, a place for the Side Deck must be put into the design. Definitely not as big as the Main Deck, the Side Deck can have up to 15 cards.

- **Life Point Value** – Besides the rare occasions in which a duel is concluded with the aid of a card’s special effect or an opponent’s inability to draw from their Main Deck, the most common win condition for a player is to reduce their opponent’s Life Point’s to zero. Conversely, a natural inclination to keep one’s Life Points high or uneventful is a key component to surviving and winning a duel. Unfortunately, because the ebb and flow of ambitious wills to emerge victorious in a game causes this value to decrease (and sometimes increase) throughout the course of a duel, this value can be hard to keep track of. Undoubtedly, though, this is a vital piece of information for a player to have during duels. While each player starts a duel with 8,000 Life Points, card effects can alter this number to well over 100,000. A display for a player’s Life Points
should be visible on the duel disk. Lastly, as mentioned earlier, in view of the fact that this value can change numerous times even throughout a single turn, it should be easily calculated by the player to reduce mathematical contemplation and thus increase game related time during a given duel.

Before moving on, it should be noted that some game options will be not incorporated into this design because of their simplistic/complicated assimilation into this product. Token Cards, which are substitutions for Monster Cards created by certain card effects but that don’t go in any zone besides the Monster Card Zone, vary in quantity and use because very specific cards must be used to play them. Playing cards from the Side Deck face-down as Token Monster Cards is an option most players use as the Side Deck is not used at all during a duel. Next, counters, that are used to keep track of card effect values, have an uncapped limit in duels and could be unmanageable if given physical representations in this duel disk’s design. A player could solve this problem with a pen/pencil and paper. Finally, coins and dice are so small in size they could easily be put in a player’s pocket. The exclusivity in their use in addition to the previous fact is a good reason to not require a place for them in this design. Despite the exclusion of these game options in this prototype, their consideration in future designs could be touched upon in later projects.

The many requirements and conveniences implemented in the prototype will be further reviewed upon the selection of the final design alternative in the final portion of this section.

User Compatibility
Having taken care of the player requirements concerning the game in this device, the next thing to look at is the player themselves. This device has to be attached to the player’s arm in some fashion to allow instant access to their cards. As the player will wear this product for an extended amount of time (as most duels can take at least 10 minutes each), creating an attachment that will comfortably fit all sizes of players is vital.

The range of compatible users for this attachment was originally set to be defined via player measurements and data. However, upon posting a player data survey on various Yu-Gi-Oh! forum websites, participation was not sufficient, and while initial data was sparse, these posts were quickly removed by administrator’s due to forum rules, not allowing for the retrieval of this information.

Not having wrist measurements to go off of other than this designer’s 24 year-old wrist, a general design was created using this 6.75in circumference. A sketch of this design is shown below in Figure D-1.

**Figure D-1: Sketch of Initial Wrist Attachment.**
It can be seen that the final circumference for this design was 10in due to the fact that adding cushion inside the attachment would reduce the diameter of the attachment. In addition to this, by adding drawstrings to each side of the attachment to further tighten it to the user, any players having a wrist circumference below 8in will be able to wear the device.

Despite this minor success, after discussing the construction details regarding this mostly fabric accessory with a clothing tailor in downtown San Luis Obispo (Rose and Henry Tailors), its assembly would be much too complicated in relation to its simple purpose – attaching the duel disk to the player. The tailor suggested a simpler alternative that although being more specific to the user would also eliminate the possibility of rotation of the duel disk, regardless of its off-centered design.

This alternative was a wrist brace that surrounded the wearer’s hand and wrist securely with Velcro straps. A small loop of cloth that goes around the wearer’s thumb prevents twisting of the brace. A supplemental advantage to this brace is that it is ambidextrous, meaning it can be used for both right and left handed users. As past duel disk products only were released for right handed users that attached to the left arm, this option would open up this prototype’s user compatibility to include left handed duelists. Unfortunately, these braces are unique to a smaller range of circumferences depending on the type of brace obtained. In lieu of this disadvantage, since these braces are already constructed and produced by a current company, obtaining the proper braces that will encompass all users would be simple. However, for testing purposes, only one brace that fits this designer will be integrated into this prototype’s design.
As this attachment option both allows for comfortable use by the gamer and expands this product’s market to left handed players as well, the following step is to combine the duel disk and attachment into the experimental prototype.

**Final Design Assembly**

The final design considered for prototype assembly is shown below in Figure D-2 (sketches of other alternatives and reasons why they were rejected are shown in Appendix A). Figure D-2 also labels various features of the design that are described in greater detail below the picture.

**Figure D-2: Labeled Image of Prototype.**

The features of the final prototype are listed below plus the reasons for their design, placement, and material selection (accompanying figures are displayed):
• **A – Main Deck Holder** – The design of this feature was particularly tricky (seen in Figure D-3). Since it’s the most frequently used area, its location had to be at the very end of the arm, making it closest to the opposite hand when the arm and device is parallel to the ground (this position will be referred to later as the Ready Position). Because the deck is occasionally shuffled during a duel, its entire removal from this area is needed, so a two-piece design with a magnetic snap keeping it closed during a duel is a simple way to achieve this. However, drawing cards is also an extremely common occurrence; to allow a player to draw cards while securing the remainder of the deck in the holder, openings along the top and front edges easily let the player have access to their deck without having to open the holder every turn. The holder is made out of plastic, with a small cloth strap holding one half of the magnetic snap that is not difficult for the player to grab. This feature makes up the Deck Holder, consisting of a Top and Bottom piece. The Bottom portion being epoxy cemented to the Core of the device and the Top being epoxy attached to hinges which is also attached to edge of the Bottom.

**Figure D-3: Main Deck Holder, various positions.**

• **B – Side/Extra Deck Area** – Since both these decks are mildly used during a duel and have the same card maximum, their locations were put at opposite ends of each other and near the center of the prototype in an attempt to balance the core of the device. When accessed, both these decks require searching through the cards within, so inserting a circular gash at the corner of these areas allows the player to swiftly grab the entire deck despite its sideways orientation. This area makes up a part of the prototype referred to as the Core, which like the Deck Holder is made out of plastic and has cloth straps with magnetic straps to keep the
cards from falling out when the arm is at rest (straight down). This feature is seen in Figure D-4.

**Figure D-4: Side/Extra Deck Area, various positions.**

- **C – Hand Holder** – Seen in Figure D-5, this allows the player to place their hand in during a duel or whenever they need to shuffle their deck. Because the hand should be in close to the player and as far away from the opponents view as possible, its location is on the reverse side of the Monster/Spell/Trap Card Areas (collectively referred to as the Field). In addition to this, the ambidextrous nature of this prototype needs it to have the ability to easily switch positions with the Monster/Spell/Trap Card Areas. This was solved by attaching (epoxy cementing) a seat belt buckle both to this feature and the Field, with the respective parts located on two sides of the Core, allowing their places to be swiftly switched. This plastic part was taken from the back of a pedometer purchased at a dollar store. While normally used to keep the pedometer fastened to a belt, it effortlessly can hold many cards but more importantly the six required for most player’s hands.

**Figure D-5: Hand Holder, with/out cards.**
• **D – Graveyard/Removed From Play Area** – As mentioned earlier, the Graveyard and Removed From Play Zones are alternative areas for cards removed from normal game play. Even though they both have a limit of 75 cards, these totals are taken from the combined limits of the Main Deck and Extra Deck. Sharing the same source of input, these combined areas can never have more than 75 cards between the two of them. This fact informed the design of amalgamating these two zones into one area (making up central cavity of the Core). The solution for separation between these two zones is to simply place Graveyard Zone cards face-up and Removed From Play Zone cards face-down. As the disposal of cards in this area is usually done incidentally, a small slot is placed at the top of the Core to flawlessly slide a card in without having to access the entire area. Moreover, the design of this area takes on a slightly parallelogram structure unlike the rectangular casings of the previously mentioned areas to force cards to slide to the bottom. This area is seen in Figure D-6 and like the other parts of the Core, is made of plastic, with a cloth and magnetic snap attachment that lets the player its entire contents when desired.

**Figure D-6: Graveyard/Removed From Play Area, inserting/receiving cards.**

• **E – Life Point Calculator** – This feature is fairly obvious to explain. It is a small 8-digit display calculator, purchased, that simplifies Life Point calculations. It’s located at the top center of the core of the prototype permitting clear visibility to the player. To reduce the amount of pieces that must change sides when used by either right and left handed users, the calculator was glued onto the top of the Core oriented such that the display is parallel to the Graveyard/Removed From Play Area’s disposal slot, so both types of users see the same, albeit sideways, display. Figure D-7 shows both possible views of the Life Point Calculator.
Figure D-7: Life Point Calculator, left and right player perspectives.

- **F – Monster Card Areas** – These, along with the following two features, make up the section of the prototype referred to as the Field. These particular areas are capable of holding down up to 6 cards due to the elastic band and bead located at the center of each area. This area, like most past duel disk designs, integrates both possible Monster Card positions by featuring an upside down T-shape. These areas like the other parts of the Field are made out of plastic and combined together using an epoxy adhesive. A close up of this area is shown in Figure D-8.

Figure D-8: Monster Card Areas, with/out cards.

- **G – Spell/Trap Card Slots** – Continuing the Field components of the duel disk, the Spell/Trap Card Slots are placed directly underneath the Monster Card Areas. As only one card is needed to fit inside, the thickness of these slots is much smaller than the height seen in the Monster Card Areas. To allow some visibility to the player when cards are in play, the depth of these slots is such that the card type and title is still in view. This feature can be seen below in Figure D-9.
Figure D-9: Spell/Trap Card Slots, with/out cards.

- **H – Field Spell Card Slot** – Last but not least, the Field Spell Card Slot is located at the bottom center of the Field. Just like the Spell/Trap Card Slots, it only requires holding one card, and its depth is short enough to keep the name information in sight. Not to reiterate past material components, a special note must be address in reference to the Field component as a whole. As discussed in the Hand Holder description, this component is fitted with a seat belt that allows it to be attached to the Core in one of two locations. In addition to this feature, the seat belt is epoxy cemented to a slightly bent obtuse metal hinge making the plane of both the Monster and Spell/Trap Card Areas partially angled when the device is at the Ready Position. This option was included to have all Field areas accessible without having to put one’s wrist in awkward angles during the placement of cards. The Field Spell Card Slot is shown in Figure D-10 as well as the angled orientation of the Field component of the prototype.

Figure D-10: Field Spell Card Slot, with/out cards; Angled Field component.

- **I – Wrist Attachment** – The final component of this prototype, in addition to the Field and Core, is the Wrist Attachment. As discussed earlier, this component was
bought (from a injury accessory store) and comfortably conforms to the wrist and hand curvatures of the wearer via Velcro Straps and a smooth cloth composition. To attach this component to the Core, an extended dual sided length of Velcro was sown onto the top of this attachment with the help of the tailor that first informed this designer about its more convenient features. In order for this strap to be effective, an area for it to lasso through was incorporated into the design of the Core, specifically the bottom. This attachment and its Core counterpart is shown in Figure D-11.

**Figure D-11: Wrist Attachment being connected to Core component.**

Before concluding this section, a word involving the creation of the plastic parts of the prototype will be detailed here. The many parts (all parts are shown in Appendix B) used in this prototype were designed in the engineering drafting program, ProEngineer Version 4.0. Upon several modifications in their designs, final configurations were then converted into a .STL format. This format is needed for Cal Poly IME Department’s Rapid Prototyping machines. Despite the unrealistic manufacturing costs involved (later discussed at the end of Results and Discussion) in this process, a solid durable prototype is needed for the experimenting portion of this project; this fact also is the reason for the
lack of hollow pockets in this prototypes design. Creating hollow sections in these pieces would significantly reduce the volume of plastic used in the RP process, in addition to the parts’ overall weight. But since thinner walls in these RP parts are susceptible to breaking, hollow features were not included. This added weight puts a negative feature into this prototype, but is predictable and necessary for later testing. All RP machines and processes were used with counseling and advisory by Martin Koch, a Cal Poly faculty member and expert in most manufacturing practices that the IME Department uses. The exact volumes associated with the various parts made are shown in Appendix C, note that support material is not seen in the final product as is serves only as a construction support and is dissolved away in a chemical bath after the RP machine completes synthesizing the parts.

As it has been excessively stressed in this section, the design of this duel disk was intensely user-centered and deliberately made to keep its use as easy as possible for the average Yu-Gi-Oh! Card Game player. Testing this prototype against a similar older product is the next step to verify if these new characteristics have actually improved the player’s gaming experience, in addition to the obvious satisfaction of previously ignored game considerations.
METHODS: TESTING THE PROTOTYPE

This section describes the methods used to design the experiment that tested the prototype. It will tell what product it was tested against, what was tested, and how the procedure was setup and analyzed.

The Academy Duel Disk Launcher

Though there are many duel disk products for the prototype to be tested against, there was only one available to this project’s designer for time and cost reasons. This product was Mattel’s Academy Duel Disk Launcher, featured on the anime series, Yu-Gi-Oh! GX and seen in Figure M-1. Though this duel disk is not the most recently released product, the sole feature unavailable in this model that is seen in more modern merchandise is a location for the Extra Deck and Removed From Play cards. Luckily, this feature is unimportant in regards to analysis as card carrying quantities are fairly objective and quantifiable and, as such, will not be subjected to testing. Because of this, what to test became the next thing to narrow down.

Figure M-1: Academy Duel Disk Launcher, made by Mattel.
Suitable Testing Objective

The new prototype, having been designed to fulfill most game requirements, has an advantage to most past products – including the one it was pitted against – as their shortcomings have guided its design. For example, while this prototype has a place to hold cards for the player’s hand, Extra Deck, Side Deck, Removed From Play cards, the Academy Duel Disk Launcher has no designated area for any of these gamer necessities. In addition, as this model did not exist in the gaming environment that had the six card maximum per Monster Card Zone mechanic, it would be unfair to compare these two duel disks just by looking at card capacity alone. This is especially true due to the fact that this project’s duel disk can hold 60 cards in the Main Deck Area, while the Academy Duel Disk Launcher can barely hold the minimum of 40. Speaking of which, the area designated for the Main Deck is not as fortified as this new prototype’s area and is known to let cards (even the entire deck) slip out when the disk is held at a player’s side.

About the only things these items have in common are areas for Monster, Spell/Trap, and Field Spell Cards. If it is assumed that a cumbersome design would cause players to take longer to complete a game task, faster times in a device will produce the superior design among the two. Testing task times between these two duel disks seems to be a fair factor for analysis; the task, of course, being the placement of a card in an area. Before moving on, however, there are some distinctions to be addressed that will affect analysis, procedure, and, in one case, inclusion in the experiment. As seen in Figure M-2, the design of the Field Spell Card Area for the Academy Duel Disk Launcher (referred to in testing as GXDD) is hidden and requires a player to pull out a compartment for placement, while this prototype (referred to in testing as SPDD) simply
has an open slot. Clearly, as the former design takes more steps to achieve the same goal as the latter, it will yield much higher task times. For this reason, the Field Spell Card Area will be excluded from testing. Fortunately the same is not true for the other two areas. The Monster and Spell/Trap Card Areas in these two designs are similar in location and orientation, so simply arranging the order in which these locations are tested should make the data produced easy to analyze. Specific analysis methods used for these areas will be discussed at the end of this section in greater detail.

**Figure M-2: GXDD’s Field Spell Card compartment, closed/open.**

**Experiment Procedures**

The experiment was designed to look at card placement times for both the Monster and Spell/Trap Card Areas. Because time for subjects was an issue, executing an experiment that would test both locations simultaneously to save time was the optioned method for testing. Lastly, because other design feature advantages are not visible though time testing, an additional task will be asked to be performed, followed by a short comparative oral survey, where user concerns can be addressed.

The following procedures made up the experiment performed on participants for both devices (applicable pictures are provided for clarification):
1. The user is asked whether they are right or left handed. Afterwards, the tested duel disk (either GXDD or SPDD) is attached to the opposite arm. Life Point Display is set at zero.

2. 10 cards are loaded into the duel disk’s Main Deck Area. See Figure M-3.

**Figure M-3: GXDD’s & SPDD’s Deck Holder, loaded with 10 cards.**

3. Subject is then asked to stand in the Ready Position (disk-attached arm is parallel to the ground and their dominant arm is at their side). Seen in Figure M-4.

**Figure M-4: Both devices, with user at the Ready Position.**

4. When given the signal, the subject will:
   a. Draw a single card from the Main Deck Area
   b. Place the card in one of the Monster Card Areas
   c. Then put their dominant hand back to their side
   d. Experimenter records time interval for the subject to return to Ready Position

5. They repeat step 4 until all Monster Card Areas are filled. Once filled, they repeat step 4 for Spell/Trap Card Areas, as well. Time testing completion condition is seen in Figure M-5.
6. Experimenter removes cards from Areas.
7. Steps 2-6 are repeated five more times.
8. Subject is asked to change the Life Point Display to 8000. They are asked to subtract 1500 from that value. Then to subtract 700.
9. Device is removed from subject.
10. Steps 1-9 are repeated for the other duel disk.
11. Once second device is tested, subject is given an oral survey composed of five comparative questions. Questions are:
   - Which device is better in terms of comfort?
   - Which device is better in terms of weight?
   - Which device is better in terms of area/card access?
   - Which device is better in terms of task ease (placement and Life Point calculations)?
   - Which device is better overall?
12. Experiment records responses based on a scale of 1-7 (1=GXDD is much better, 4=Equally Good, 7=SPDD is much better). Task times and survey results are shown in Appendix D.
13. Subject is asked to comment on either duel disk.
14. Experiment is concluded.
Analysis Method

Because task times are the observations under analysis, determining if there is a significant difference in the two devices is vital to concluding which design is better. However, any possible biases must first be eliminated either in the analysis or the experimental procedure. Having so many repetitive tasks, fatigue may develop during testing, making the second duel disk tested produce longer times. Inversely, this repetition can also make these tasks more familiar and thus more rapidly carried out (known as a learning curve). In either case, the second device is subject to a bias. To account for this two things are done. One: the subject pool is divided into two groups, in which the starting duel disk is switched between the groups (Group 1 starts with GXDD then SPDD, Group 2 starts with SPDD then GXDD). This counterbalances the data and helps produce fair statistics. The second thing done to remove the bias is to analyze the data using a paired t-test. Though the dataset for each condition (Group 1 Monster Zones, Group 1 Spell/Trap Zones, Group 2 Monster Zones, and Group 2 Spell/Trap Zones) is 60 points, the standard deviation for the population is not known, so a student test must be used (t-test). But as each subject is subjected to both duel disk experiments, half the data is dependent on the first half. This dependence calls for a paired t-test to account for this bias.

Now that the methods for experimentation have been thoroughly explained, the results of these experiments will be reviewed.
RESULTS & DISCUSSION

This section will state and discuss the results of the experiments/surveys that compared the two duel disks. It will conclude with a short summary of the economics produced for this project.

Experimental Results

The results for the experiment were divided into 4 conditions, all of which were subjected to a paired t-test. The null hypothesis for all of these conditions states that the mean value between the devices is equal; inversely, the alternative hypothesis states they are not equal. Also, the confidence interval is 95%. The conditions, results and implications are given below (the results of the ANOVA tests, performed by the statistical analysis program, MiniTab 16, can be seen in Appendix E):

- Group 1-Monster Zones: the p-value for the given data was 0.280. Because the p-value is greater than 0.05, the null hypothesis is not rejected. This means there is not a significant difference between these devices.

- Group 1-Spell/Trap Zones: the p-value for the given data was 0.000. Because the p-value is less than 0.05, the null hypothesis is rejected. This means there is a significant difference between these devices. As SPDD has a smaller mean (4.288 seconds) than GXDD (5.376 seconds), SPDD produces faster (lower) task times for placing a card in a Spell/Trap Zone.

- Group 2-Monster Zones: the p-value for the given data was 0.084. Because the p-value is greater than 0.05, the null hypothesis is not rejected. This means there is not a significant difference between these devices.

- Group 2-Spell/Trap Zones: the p-value for the given data was 0.016. Because the p-value is less than 0.05, the null hypothesis is rejected. This means there is a significant difference between these devices. As SPDD has a smaller mean (4.882 seconds) than GXDD (5.430 seconds), SPDD produces faster (lower) task times for placing a card in a Spell/Trap Zone.
Based on the ANOVA results, it seems that (SPDD) the prototype’s design allowed for faster task times for the placement of cards into the Spell/Trap Zone. This may be due to the fact that the prototype’s Field component is at an angle, which makes access to the Spell/Trap Card Slots much easier than the Academy Duel Disk Launcher. The data also shows that there is no significant difference in the two devices in terms of Monster Zone card placement. It was seen, during testing, that drawing cards from the prototype’s Main Deck Holder was confusing for subjects at first. While in the GXDD, drawing cards was very intuitive because the cards were not completely surrounded (see Figure R-1).

Subjects also commented later that the prototype’s Field area was more visible than in the GXDD (which has its “field” split into two, two on one side and three on the other). They felt this made their reaction time for where to place cards quicker in SPDD than GXDD.

As ‘drawing a card’ and ‘placing it down’ were the two components that made up the task times, this tradeoff between devices may have balanced out in the long run, producing the non-significant results observed. Speaking of subject commentary, let’s look at what the survey produced.

**Figure R-1: User drawing a card from SPDD’s & GXDD’s Deck Holder.**
**Survey Results**

As seen in Appendix D, the survey produced mixed to favorable outcomes. Looking at the mean values for these scores, it is observed that GXDD was slightly better in terms of comfort, weight, and access. Anticipating the failure of the prototype in terms of weight, this may have also affected the users comfort. Only having one score of 6, SPDD did not do well in terms of access. As mentioned earlier, the Main Deck Holder was somewhat difficult to work with for some and might have affected the results of this portion of the survey. On the flipside, SPDD won in the categories of task ease, visibility and overall superiority. The data showed that the prototype did have significantly lower times for Spell/Trap Zone card placement which means it was easier for them to complete this task. So, this consequence could have generated this positive result. In addition, visibility was commented to be better in SPDD as opposed to GXDD’s split interface. Thus, a score of slightly better (4.5) is reasonable for the prototype. Finally, after everything was said and done, it seemed that the project’s prototype had an overall score of just between better (5). This says that, with all its flaws in the first three areas of criticism, all the subjects considered SPDD to hold the superior design. This, along with the data results, illustrates that the newly-designed prototype is an improvement over a past product of similar functions.

**Economic Summary**

Because the persistent goal of this project was to improve the design of the duel disk and to not create a marketable product, economic justification for this product’s creation verses the market price of the current products (which ranges from $50 to $200) is outside of the scope of this project. However, as economic costs for the creation and
research of this prototype are not irrelevant to this project, it will be reviewed here. First, there is the cost of the prototype itself, which as seen in Appendix F, is $478.01. As the cost of Rapid Prototyping materials were about $5 per cubic inch, the cost of RP was a giant portion of the prototype costs. Also, not including the cost of paint, which was not essential to the creation, the final cost to mention was the cost of the experiment. Despite the fact that only four participants took the bait of pizza as an incentive to participate in the experiment, the total cost of the experiment (including food, drinks, utensils, plates and cups) was $58.90. All in all, ranking up a total bill of $536.91, this project was definitely not a negligible investment.
CONCLUSIONS & RECOMMENDATIONS

This section will briefly summarize the conclusions taken from this project, its experiments and their results. A recommendation based on these findings will also be touched up, to aid future designers and experimenters interested in this topic.

Summary

The main objectives of this project which were to design a Yu-Gi-Oh! table-free product that suited the players, adhered to their gaming needs, and improved on similar product’s deficiencies were, for the most part, accomplished. A working prototype was created and tested against a past product of similar utility. After tests and surveys, it was shown that this new device had partial areas that produced statistically significant lower task time values. Its overall design was favored by participants and in the data, succeeding to improve player interface as well as satisfying most game requirements. Despite the reevaluation of a design goal, its utilization was superior to its rival device.

Recommendations

Because of the lack of manufacturing cost estimates associated with this project’s product, it is recommended that if this design were to follow through into market production methods that significantly reduce the weight would further aid in its user desirability and produce a valid market model for comparison against past designs. Obviously, Rapid Prototyping is not an effective manufacturing tool; rather, if plastic is still its main component, a plastic molding alternative should be investigated. On the other hand, using cloth or cardboard could also greatly decrease costs and product weight. Incorporating a belt accessory into its design for carrying the many decks used in a game would be an interesting way for future designers to reduce weight during use as
well. Lastly, for future experimenters, due to subject confusion caused by some design features, extended training for each product could eliminate disorientation during testing.
APPENDICES

APPENDIX A: ALTERNATIVE DESIGNS

Sketches of Alternative Duel Disk Designs.
APPENDIX B: PART DRAWINGS

ProEngineer Drawing of Deck Holder-Bottom.

ProEngineer Drawing of Deck Holder-Top.
ProEngineer Drawing of Monster & Spell/Trap Area.

ProEngineer Drawing of Core.
ProEngineer Drawing of Field Spell Area.

ProEngineer Drawing of Field Divider.
ProEngineer 3-D Assembly Image of Prototype
APPENDIX C: PART VOLUMES

Breakdown of Part Volumes for Rapid Prototype Processing.

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**APPENDIX D: TASK TIMES & SURVEY RESULTS**

### Task Times for Experiment of Both Duel Disks.

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### Comparative Survey Results following Experiment of Both Duel Disks.

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55
APPENDIX E: ANOVA ANALYSIS

ANOVA Results for Group 1 - Monster Zones.

**Paired T-Test and CI: M-GX, M-SP**

Paired T for M-GX - M-SP

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<tr>
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95% CI for mean difference: (-0.553, 0.163)
T-Test of mean difference = 0 (vs not = 0): T-Value = -1.09 P-Value = 0.280

ANOVA Results for Group 1 - Spell/Trap Zones.

**Paired T-Test and CI: S-GX, S-SP**

Paired T for S-GX - S-SP

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95% CI for mean difference: (0.556, 1.620)
T-Test of mean difference = 0 (vs not = 0): T-Value = 4.09 P-Value = 0.000

ANOVA Results for Group 2 - Monster Zones.

**Paired T-Test and CI: M-SP2, M-GX2**

Paired T for M-SP2 - M-GX2

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95% CI for mean difference: (-0.031, 0.475)
T-Test of mean difference = 0 (vs not = 0): T-Value = 1.76 P-Value = 0.084

ANOVA Results for Group 2 - Spell/Trap Zones.

**Paired T-Test and CI: S-SP2, S-GX2**

Paired T for S-SP2 - S-GX2

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95% CI for mean difference: (-0.990, -0.106)
T-Test of mean difference = 0 (vs not = 0): T-Value = -2.48 P-Value = 0.014
Data Set for ANOVA Analysis.

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### Economic Breakdown of Prototype Material & Experiment Costs

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BIBLIOGRAPHY


Evaluation of human factors in interface design in main control rooms. Hwang, Sheue; Liang, Sheau-Farn Max; Liu, Tzu-Yi Yeh; Chen, Po-Yi; Chuang, Chang-Fu.


