He Hit First - An Analysis of Mixed Martial Arts Matches to Determine The Significance of the First Strike

Heidi Julia Kylmälä

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Instructor: Jussi Palomäki

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Tiivistelmä – Referat – Abstract

The aim of this thesis is to investigate the effects of the first hit in a round of mixed martial arts competition. The theoretical background comes from theories of psychological momentum. Following these theories, if the first hit is a robust starting point for positive and/or negative psychological momentum, the effect should show in the amount of hitting following the first attack. Perspectives for both self defence and combat sports are considered.

Psychological momentum as a phenomenon remains controversial. It has previously been investigated in sports contexts where the opposing player's actions have an effect on the other player. In a mixed martial arts match that effect is more immediate due to the physical proximity of the fighters to each other.

Data was gathered both by viewing Ultimate Fighting Championships matches and from the Fight Metric website, which holds records for all Ultimate Fighting Championships matches. The data consists of a total of 104 matches. A series of linear mixed models is fitted to predict the first attacker's total strikes based on the opponent's reaction, and a contrast analysis is used to compare the conditions based on reaction. The main result is that on the third round of the match, if the fighter who hits first is blocked, he or she will hit more during that round.

The conclusion is that the fighter attacking first strikes more if his or her attack is blocked, but only on the third round. While this implies that the third round is different from the first two, the reason for that is unclear. This finding can be used to inform combat sports coaches' strategies, and should motivate further investigations to the significance of the first attack in both self defence situations and in combat sports.

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Tämän tutkielman tavoite on selvittää ensimmäisen lyönnin merkitys vapaaotteluerässä. Teoreettisena pohjana tutkimukselle käytetään psykologinen liikevoima -ilmiötä kuvailevia teorioita. Näiden teorioiden mukaan, jos ensimmäinen osuma on riittävä lähtökohta positiiviselle ja/tai negatiiviselle psykologiselle liikevoimalle, vaikutuksen tulisi näkyä lyöntimäärässä ensimmäisen hyökkäyksen jälkeen. Näkökulmia tarkastellaan sekä itsepuolustuksen että kamppailu-urheilun näkökulmista.

Ilmiönä psykologinen liikevoima on edelleen kiistanalainen. Sitä on aiemmin tutkittu urheiluympäristöissä, joissa vastapelaajan toiminta vaikuttaa toiseen pelaajaan. Vapaaottelussa tämä vaikutus on välittömämpi, koska kamppailijat ovat fyysisesti huomattavasti läheisemmässä kontaktissa.

Dataa kerättiin sekä katsomalla Ultimate Fighting Championships -otteluita että Fight Metric -sivustolta, joka kokoaa tiedot kaikista Ultimate Fighting Championships -otteluista. Data koostuu yhteensä 104 ottelusta. Ensimmäisen hyökkääjän kokonaislyöntimäärää ennustetaan sarjalla lineaarisia sekamalleja ja reaktiotilanteita verrataan kontrastianalyysilla. Päätulos on, että jos ensimmäinen hyökkäys torjutaan ottelun kolmannessa erässä, lyö ensimmäisenä hyökännyt ottelija enemmän erän aikana.

Tästä voidaan päätellä, että ensin hyökkäävä ottelija lyö enemmän, jos ensimmäinen hyökkäys torjutaan, mutta vain kolmannessa erässä. Tämä tarkoittaa, että kolmas erä eroaa kahdesta ensimmäisestä erästä, mutta syy siihen on epäselvä. Tätä havaintoa voidaan käyttää hyväksi kamppailu-urheilun valmennusstrategioissa, ja sen tulisi motivoida lisätutkimuksia ensimmäisen hyökkäyksen merkitykseen sekä itsepuolustustilanteissa että kamppailu-urheilussa.

Avainsanat – Nyckelord – Keywords
itsepuolustus, kamppailuntutkimus, kognitiotiede, psykologinen liikevoima, päätöksenteko
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1 Introduction

In recent years, the extremely physical and mentally challenging adversarial setting of mixed martial arts (MMA) matches has started to gain interest in the academic world. After the dawn of Ultimate Fighting Championship (UFC) tournaments in 1993, similar organizations started to appear and gain publicity. The UFC remains the most well known, and the easiest to get data on. This Master's thesis focuses on MMA fight data gathered from UFC events.

According to my best knowledge, MMA has not been a focus of any academically published decision making research. This might be due to the relative novelty of the sport, and the research into it focusing mainly on injuries. In this Master's thesis I operate under the assumption that from a strategic viewpoint, MMA is in some respects similar to other fast-paced strategy games, such as speed chess and tennis. Due to the similarities, the same line of theories and analytical methods can be used to interpret the data.

Despite the UFC's popularity being a somewhat new phenomenon, MMA as a sport has been around some time: Brazil has seen Vale Tudo ("everything goes") matches since the 1920's (Parman, 1994), and ancient Greek olympics had the sport pankration ("all of power"), which mixed boxing and wrestling with only two rules, from 648 BC until the rise of the Roman empire (Poliakoff, 1987).

The term *no holds barred* (NHB) is defined as a fighting match that has no or almost no rules. It was the term used for UFC fights in the early 1990's, and although it is often (erroneously) used synonymously with MMA, it should be made clear that these terms mean different things: *no holds barred* was a translation of *vale tudo*, the term that was used by the Brazilian Gracie family for their promotions of Brazilian jiu-jitsu (Parman, 1994), whereas MMA simply means any competition not restricted to the rules of a specific fighting style (for example judo, boxing, or karate). Single-style competitions usually adapt rules that are most fitting for the style in question, for example wrestling doesn't allow punches, and boxing doesn't allow takedowns. MMA competitions have rules that try to assure no one style is favoured, giving points from both ground and stand up techniques. Today, MMA can also be considered a style of its own with a distinct set of rules.

The UFC is the most well known format of MMA fighting today. Due to its grown rule set to appease the critics and sports commissions, it can no longer be called NHB fighting, since many holds - 31 to be exact, as of 2017 (Rules and regulations, n.d.) - are, indeed, barred.

The development of the fight is interesting from a psychological perspective. In the self-defence community there are certain beliefs about the impact of the first hit in a self defence situation. It is believed that hitting first is beneficial, and this is sometimes attributed to the first hitter "asserting dominance". This "word on the street" slightly parallels a phenomenon known as psychological momentum. Psychological momentum is a phenomenon wherein a person competing in, for example, a sports contest, experiences a shift in their performance, either positive or negative. Peter Adler first defined momentum as "a state of dynamic intensity marked by an elevated or depressed rate of motion, grace, and success" (from Taylor & Demick, 1994, p. 52), and this definition still stands current. Since the days of Adler, the whole phenomenon has been called into question. Some studies have managed to find an effect, while others have failed, and yet others have critiqued the methods of both the successful and unsuccessful studies. Still, the belief in the phenomenon persists in the layman sports community, and research continues.

This thesis investigates the momentum phenomenon from a slightly different perspective. I'm going to analyze data gathered from UFC matches, trying to determine if the first attack in a competitive fight has any effect on how much the fighters attack during the rest of the fight. If the first initiative indeed would prove meaningful, it would suggest the presence of psychological momentum phenomenon in fight settings. Of course, the absence of effect would not necessarily prove the absence of the psychological momentum phenomenon in fights altogether. It might very well be the case that the first attack isn't a robust starting point for momentum for everyone - or at all.

This study may also give some perspective for the efficacy of attacking first in a self defence situation. Since a consensual, sportified fight between two expert fighters is a very different context from a nonconsensual self defence situation, the results of this study will merely provide perspective and avenues for further research into the world of self defence. Again, from the absence of meaningful results it would

not be possible to conclude that the first attack in a self defence context doesn't matter, but it would suggest a need for the "word on the street" to be called into question and researched further.

In this chapter I'm going to take a look at the history of NHB and MMA fighting and previous research into the subject, as well as into the research into the psychological momentum phenomenon. The second chapter outlines the methods I used for this study. The results of the current study are reported in the third chapter and analysed in the fourth.

1.1 A Brief History of the UFC

The history of fighting without rules is as long as the history of conflict in general, although it is impossible to say for sure when it was made a pastime for leisure and competition. One of the first recorded examples of fighting with very sparse rule sets is the Greek Olympic sport pankration ("all of power", from Greek *pan*, all, and *kratos*, strength or power). It first appeared in the Greek olympics in 648 B.C.E., and the only two rules banned biting and eye-gouging. (Poliakoff, 1987; see also Georgiou, 2008) Due to the lack of evidence for a similar sport in the Near East at the time, and the fact that athletes were not, by far, considered military assets, Poliakoff (1987, p. 54) suggests that the sport developed in the Greek society to meet the need for violent expression, much like other authors, such as Sanchez Garzia and Malcolm (2010), have suggested modern MMA formats have developed in today's society.

After the ban of the Olympic sports, pankration was forgotten. There are no records of similar fighting concepts being practiced for hundreds of years (although this does not mean they weren't), until the 1920's, when the Brazilian Gracie family introduced their brand of jujutsu in *vale tudo* (anything goes) matches. Carlos Gracie Sr had learned judo from a Japanese immigrant and master of the art, Mitsuyo Maeda. Gracie, with his brothers, adapted the art to a more effective form, which they taught to their children. (Downey, 2007) This is the martial art that later became known as Brazilian jiu-jitsu (BJJ), a style that is still held in high regard for its success in MMA. The first proof of this was the Gracie Challenge, when Carlos

Gracie published in a newspaper an open invitation for any fighter to come challenge him. The cash prize offered by Gracie was rarely claimed by the challenger. (Parman, 1994)

The first UFC match in 1993 was the result of Carley Gracie bringing their style into the United States of America, with the explicit intent being to find out which of the contemporary martial arts was "the best" - and the implicit intent being to demonstrate that it was BJJ. It turned out that Gracies' BJJ indeed was the best - Royce Gracie went on to win all three of his tournament matches, bringing home the $50 000 prize money. In this effect, as a demonstration of BJJ, the purpose of the UFC had been fulfilled.

The very first UFC match bore a very close resemblance to pankration - there were no weight classes, no gear requirements, and no rules - except to ban biting and eye-gouging (van Bottenburg & Heilbron, 2006). During its formative years, the UFC went through various rule changes: the boundaries evolved to optimize entertainment value and safety of the competitors. However, despite these efforts, the UFC has faced some challenges from the lawmakers, many politicians lobbying to make the fighting format illegal. Today the UFC is a recognized sports format sanctioned by most state athletic commissions of the United States of America.

Due to the continued success of BJJ, the composition of the fighters' styles has changed dramatically. The early years saw highly specialized fighters (specializing either as strikers or grapplers), whereas now the fighters tend to be more well rounded, even when they have a preference for either stand-up or ground game. MMA has become a sport in itself, pitting individual versus individual, instead of a showdown between different arts.

Other MMA promotions have also appeared since the dawn of the UFC, but they have rarely reached the same levels of popularity. Competing promotions include such titles as the international Xtreme Fighting Championship and the Japanese Pride FC.

With the UFC 5, singles matches (where a fighter only fights one opponent during the event instead of advancing in a tournament) were introduced to the format, and became the norm in the following years. The rules were in constant flux

between the early matches, but have since settled down. In 2017, the relevant rules for this study were the following:

- Matches may end via submission, when a contestant either verbally or physically "taps out", signaling submission; via knock-out (K.O.) when a contestant is rendered unconscious by a strike or a kick or when an injury resulting from a legal move is severe enough to terminate the fight; via technical knock-out (T.K.O.) when the referee stops the contest; or when the time runs out.
- If the time runs out, the match is decided by three judges. This can result in either a decision or a draw, which are further split into three categories: unanimous, split, and majority depending on how the judges vote.
- The clothing, protective gear, and other aspects of the competitors' appearance are standardized and checked before the match, as is the competitors' compliance to the weight limit in his or her weight class. (Rules and Regulations, *n.d.*)

1.2 Previous Research into MMA

Research into MMA and NHB fighting has been relatively scarce. A review by Bishop, La Bounty & Devlin as recently as 2013 claimed to be comprehensive, even though it only had four categories for the articles (which were (1) MMA components, (2) injury epidemiology, (3) sport-specific training and (4) motives for consumer consumption). The greatest abundance of papers can be found from the field of sports medicine - the violent nature of the sport as well as the public uproar surrounding it has warranted studies about injuries.

The violence has also raised the question if NHB fighting can even be classified as a sport. Van Bottenburg & Heilbron (2006), in their article on de-sportization of fighting contests, define the process of *sportization* as the adding of rules and judges to make the contest more safe and game-like, and introducing the concept of "good sport" (p 262). Following this, they see the first years of the UFC, with its scarce rule set and focus on catering to the audience that was less

interested in technical aspects and more so in seeing something transgressive happen in the cage, as an example of *de-sportization* of the recreational pastime of hitting people. The subsequent increase in rules they describe as *re-sportization*.

Surprisingly, there are a few other sociological papers about MMA and NHB fighting. Using the UFC as his reference point, Downey (2007) studied the human body in a combat situation as a tool, and fighting skills as technologies. He concludes that the human approach to things even as simple as self-defence seems to be through "science-like traits and technological processes" (p. 220). The American news media coverage of MMA matches has also been studied by Santos, Tainsky, Schmidt and Shim (2013). Since the media is tightly entangled with politics surrounding the subject matters, their focus was on how MMA fights are framed by different outlets. They found that the media roughly divides into two stances: one framing UFC as simply a combat sport among others, and one framing it as "human cockfighting", a savage pastime that should not be allowed.

The matches themselves have been previously analysed for effects. Del Vecchio, Hirata, and Franchini (2011) studied the effort-pause ratio in MMA matches. Effort-pause ratio is defined as the ratio by which the competitors commit to either high-effort or low-effort actions compared to resting periods. They compared their results to previously found effort-pause ratios in judo, karate, kickboxing, wrestling etc. It appears that the rounds in MMA matches have a similar effort-pause ratio to tae kwon do and brazilian jiu-jitsu, but when they considered the one-minute pause between the rounds, the effort-pause ratio dropped to that similar to judo.

Other statistical analyses have focused on winning styles. Hackett and Storey (2017) predicted fighter behaviour by balancing the fighters' data with the trends in MMA. They found that the winners tend to represent a narrow selection of styles: the styles that develop dynamic striking and the ability to set the pace of the fight tend to breed winning strategies. Winning strategies include having the cardio and determination to win by decision, the ability to use knees and elbows, and the command of the most successful submissions (which, according to their analysis, are *kimura*, rear naked choke, and a handful of other locks and chokes applied with arms from strong control positions).

1.3 Psychological Momentum and the "Hot Hand" Phenomena

The psychological momentum effect (sometimes also referred to as the "hot hand" phenomenon, especially in basketball), is a theorized effect wherein a player plays better after a win or another kind of success. The effect is bi-directional, and the cognitive reasoning goes as follows: during a competition, after a player does something right, he or she feels good about it and then performs better as a result. In reverse, after a failure, a player gets discouraged and doesn't perform as well. It is theorized that there exists a cognitive component between the good or bad feeling and a better or worse performance, but there is not, as of yet, a universally accepted description of the process. Taylor and Demick's (1994) momentum chain, described below, offers one suggestion for just that.

The psychological momentum effect itself is a controversial subject. Many athletes and spectators alike report experiencing and witnessing it, but the empirical evidence for its existence is conflicting. Crust and Nesti (2006) in their review argue that the term itself is badly defined, and would encourage qualitative research methods to better frame what is even meant when researchers are talking about the momentum phenomenon.

The first attempt to conceptualize the phenomenon was by Adler (1981). He proposed a five component model, and though it was a great step forward in theory development, it was lacking and imprecise in many aspects (Taylor & Demick, 1994). Since Adler's attempt to articulate the subject, three major theories about psychological momentum have been proposed. The Antecedent-Consequences Model of Vallerand, Colavecchio, and Pelletier (1988) was the first one, and it described the phenomenon as a sense of "moving towards a goal", affecting motivation, perception of control and such (Crust and Nesti 2006, p. 2). It was the first theory to suggest that the subjective experience and perception of the situation were important for the phenomenon. It also suggested the phenomenon to be physiological and mediated by increased arousal, possibly interfering with tasks that require fine motor skills. Later evidence, however, found the effect from tasks requiring just that: Adams (1995) reported to have found the effect in a study using pocket billiards. This suggested that the phenomenon might be cognitive instead.

In 1994, Taylor and Demick proposed the Multidimensional Model of Momentum. In their article they review the contemporary research so far, which suggests that due to hazy operationalizations, there are alternative explanations for the results of previous studies. They point out three studies that they deem to be based on clearly articulated theories: the Vallerand, Colavecchio and Pelletier (1988) mentioned earlier; Miller and Weinberg's (1991) research on both hypothetical and recorded volleyball games; and Silva, Cornelius, and Finch's (1992) laboratory study with a one on one competitive motor task. All three studies failed to find significant performance results that could be attributed to the momentum effect. Based on this, Taylor and Demick went on to search for possible intervening factors that could be masking the effect.

They defined momentum as "a positive or negative change in cognition, affect, physiology, and behavior caused by an event or series of events that will result in a commensurate shift in performance and competitive outcome" (p. 54). Based on this definition, they proposed a chain of occurrences, which they termed *the momentum chain*. Its elements are a) precipitating event or events, b) change in cognition, affect, and physiology, c) change in behavior, d) a consistent change in performance, e) a contiguous and opposing change in the previous factors by the opponent, and f) a resultant change in the immediate outcome. Step e) suggests that, for the momentum phenomenon to occur, it isn't enough for one player to experience positive momentum. In a head to head competition (such as a mixed martial arts match), the other player must also experience negative momentum from the precipitating event, for the phenomenon to occur.

Another relevant observation from them, based on the findings of Adler (1981) and Silva et al. (1988), was that experts and novices may process the precipitating events differently. In the vein of Adler (1981), similar events follow each other, meaning that success is an upwards escalator, and failure a downward spiral. Silva et al. (1988) bring up two other possible reactions they call positive inhibition, in which experiencing a positive outcome makes the player more susceptible to failure in the next round by inhibiting something needed for good performance, and negative facilitation, in which the player compensates for negative outcomes by performing better on subsequent rounds. Taylor and Demick (1994) posit that

novices fall prey to Adler's downward spirals and Silva et al's positive inhibitions, whereas professionals have learned to harness these phenomena and make them work for them, experiencing the upwards escalator of success and the negative facilitation.

The results of Taylor and Demick's (1994) two initial studies found some support for their model. In their first study, a trained observer watched professional tennis games and recorded the occurrences of previously defined cases of precipitating events and the scoring pattern following them. The study found that winning players experienced significantly less negative precipitating events (18.7 %) than losing players (68.9 %), and significantly more positive events (81.3 %) compared to the losers (31.1 %), and that they resulted in positive immediate outcomes more often.

The second study was similar in analysis, but the videos were of NCAA men's basketball games. This second study didn't find any significant difference between the winning and losing teams' proportions of negative and positive precipitating events, but a near significant result occurred when they included a presence or absence of a change in immediate outcome. The study also found that in the presence of a precipitating event a change in immediate outcome occurred with significant regularity. This suggests that it is much harder for a team to complete the momentum chain than it is for an individual to do so.

The projected performance model of Cornelius, Silva, Conroy and Petersen (1997), in contrast, claims that the momentum phenomenon is rather a result of changes in performance, and not the cause. In an earlier study measuring both perceived and actual performance, Silva, Cornelius and Finch (1992) measured performance and perceptions of momentum in a novel maze drawing task. They found significant perceptions of momentum, but no link between perceived momentum and actual scores in the task. The 1997 study pitted participants against each other in a match of throwing basketballs into the basket. The participants answered questionnaires between and after the rounds. The study provided similar results to the earlier one, finding significant perceptions of momentum, but no real connection to the actual performance. Information about the subjects' performance compared to the competitors' performance seemed to influence their perception of

momentum, which leads Cornelius et al (1997) to the interpretation that the momentum phenomenon might be a result of winning, and not its cause. In other words, psychological momentum phenomenon might just be an example of what Tversky and Kahneman (1974) list as a biased heuristic about regression towards the mean.

A recent meta-analysis on the hot hand phenomenon (Avugos et al, 2012) also indicated that the hot hand is an illusion. It analyzed 30 studies and 58 independent effect sizes, concluding that a mean positive effect size of .02 ($p = .49$) suggests no real effect. The studies analyzed included individually-performed sports, which could be seen as analogous to combat sports.

After the meta-analysis, some relevant studies on psychological momentum were still conducted. Gernigon et al (2010) studied the link between psychological momentum and anxiety, based on the assumption that a sports contest can present as a situation of high importance to the player. According to them, a player not confident in this situation would feel threatened, and thus anxious, and this anxiety could be linked to negative momentum. A study by Briki et al (2012) built on this research, showing that the power output of cyclists perceiving a start of negative momentum rapidly decreased. This is an important finding, since in a fighting context such a dip in effort can be assumed to be important for the outcome.

A working paper by Miller and Sanjurjo (2014) points out a bias in the seminal studies in hot hand fallacies. They claim that basketball studies often fail to control the environment sufficiently, and thus fail to find any statistically significant instances of hot hand and momentum. According to them, such instances get diluted by "cold hand", the negative version of momentum, and situations where there is pre-streak shooting but no follow up. To fix this, they studied semi professional basketball players who made shots from a fixed position, from a distance where they would make about 50 % of their shots. They used a novel statistical method to study the streakiness of their subjects' shooting. The detailed description of their method can be found in the paper. They also analysed a previous study by Jagacinski, Newell, and Isaac (1979) using the same method. With both of their data, they were able to tease out a significant effect both in individual and pooled analysis

In conclusion, the status of the psychological momentum phenomenon is still controversial. However, there are some differences between the previous research and the current one, that validate the purpose of this study. The next chapter outlines the current research and the main differing points.

1.4 The Current Study

This master's thesis tries to contribute to the evidence for and against the existence of the psychological momentum phenomenon by asking if the first attack in an MMA match is significant in determining which of the fighters hits more. For instance, if the first fighter to attack lands the hit, and that fighter also hits more during the round altogether, it might indicate that the fighter has gained positive psychological momentum allowing him or her the confidence to be more aggressive. Alternatively it might indicate that the fighter receiving the first hit gains negative psychological momentum, resulting in him or her adopting a more careful strategy.

When it comes to data, the previous research differs in some way from the current one. For example, the maze study of Silva, Cornelius and Finch (1992) employed a simple fine motor task, which was novel to the test subjects. The data in this study comes from situations where the competitors engage in a highly familiar, physical task in which one set is considerably longer than the 15 second maze runs used in the study by Silva et al. Another major difference to the other studies is that this study doesn't have any data on perceived momentum, only the precipitating event and the following scores. It is thus impossible to say if the competitors or the spectators experienced momentum. This study doesn't consider itself with the *perception* of psychological momentum, but instead focuses on exploring the link between the first strike and its effects on the rest of the fight. If a link is found, it would suggest that the momentum phenomenon is present in mixed martial arts, but lack of it doesn't necessarily tell us anything about the absence of the phenomenon itself.

This study will also provide insight into an optimal preparation for a match. If the first hit indeed is significant, this should affect the game plans of fighters in the future. Intuitively, and with the assumption that some kind of a momentum balance is

in play during MMA matches, it would make sense that the first hit would result in more hitting from either the first hitter or the receiver of the hit. In contrast, if there was no momentum dynamic, the fighter who hits more would vary.

2 Methods

In a UFC match, the fighters fight in an octagon shaped cage which has padding on the fence posts, and a flexible canvas covering the ground. The octagon has two entrance gates on opposing sides, from which the fighters, respectively, enter. The exterior of the octagon spans 11.5 meters in diameter, and the interior is 9.1 meters across. The cage rests 1.2 meters from the ground, and the fences stand 1.8 meters tall. Picture 1 shows the octagon in use. The matches are recorded on video and are available on several video streaming services dedicated to sports.

Picture 1. Respect bout. (*Brimelow, L., n.d.) Shot of The Octagon from UFC 74 featuring Clay Guida vs. Marcus Aurelio.*

2.1 Data Collection

I used the services of UFC Fight Pass (https://ufcfightpass.com/) to view recordings of UFC events from 21st April 2018 through 10th November 2018, and to record by hand the relevant first strike variables. The time frame was determined by recency. I viewed a total of 105 matches, since time restrictions didn't allow for gathering a larger sample. Only the *main card* matches from UFC numbered events and Fight Nights were selected to ensure the data would be as homogenous as possible, meaning that all the fighters would be the most skilled ones currently fighting in the UFC. Since the majority of the matches were of the three round format (i. e. the fighters fought for a maximum of three rounds, lasting five minutes each) and only 22 of the five round format, I dropped the last two rounds of five round format matches. I excluded matches ending in a K.O. or T.K.O. after the first attack, since the study focused on how the fighters behaved *after* the first attack.

Some individual fighters appear in multiple matches, which would have been a problem if the total amount of strikes was used as a dependent variable. The fighters have individual styles of fighting, including fighter specific tendency to strike more or strike less. However, since (1) the amount of striking by a fighter is also dependent on the fighting style of the opponent, and (2) I used a ratio between the fighters as the dependent variable, the repeat fighters could be treated as unique, even if the observations are not strictly independent. Based on these, I made the judgement that the fighter identity was unimportant. From a total of 210 fighters, there were 188 individual fighters. 20 fighters appeared twice and two fighters appeared three times.

When a match goes on for the full three or five rounds, the winning fighter is determined by judges' decision. Attacks (e. g. strikes) influence this decision, making strikes and the results of the match not independent. This is why I did not use the result of the match in the analysis. In total, 49 matches ended in a decision, 18 ended in a submission, and 38 ended in a K.O. or a T.K.O. One match ending in a decision was dropped from the data due to it being a draw. Even though the result of the match was not of interest, I considered a single draw as an outlier and excluded it. In the final analysis, I used a total of 104 matches. Since the data I used was a bit unusual, I have included an excerpt of the data, which can be examined in table 1.

Table 1

An excerpt of the tabulated data showing part of the data used in analysis.

khnro	method	name_f0	name_f1	round	f0_first_att	first_att_val	att_val	total_str_f0	total_str_f1	...
1	Submission	Donald Cerrone	Mike Perry	1	0	2	0	10	11	
2	Decision - Unanimous	Raquel Pennington	Germaine de Randamie	1	1	0	1	14	29	
2	Decision - Unanimous	Raquel Pennington	Germaine de Randamie	2	1	2	3	20	24	
2	Decision - Unanimous	Raquel Pennington	Germaine de Randamie	3	0	2	0	18	38	
3	Decision - Unanimous	Beneil Dariush	Thiago Moises	1	1	0	1	34	9	
3	Decision - Unanimous	Beneil Dariush	Thiago Moises	2	0	0	0	42	5	
3	Decision - Unanimous	Beneil Dariush	Thiago Moises	3	0	0	0	37	6	
4	KO/TKO	Maycee Barber	Hannah Cifers	1	0	2	0	43	52	
4	KO/TKO	Maycee Barber	Hannah Cifers	2	0	2	0	35	8	
5	Decision - Split	Michael Trizano	Luis Pena	1	1	2	3	11	9	
5	Decision - Split	Michael Trizano	Luis Pena	2	0	2	0	20	14	
5	Decision - Split	Michael Trizano	Luis Pena	3	0	0	0	24	11	
6	KO/TKO	Chan Sung Jung	Yair Rodriguez	1	1	0	1	31	23	
6	KO/TKO	Chan Sung Jung	Yair Rodriguez	2	0	2	0	25	33	
6	KO/TKO	Chan Sung Jung	Yair Rodriguez	3	1	1	2	24	22	
6	KO/TKO	Chan Sung Jung	Yair Rodriguez	4	1	1	2	25	19	
6	KO/TKO	Chan Sung Jung	Yair Rodriguez	5	1	1	2	25	32	
7	Submission	Daniel Cormier	Derrick Lewis	1	0	2	0	35	4	
7	Submission	Daniel Cormier	Derrick Lewis	2	1	2	3	7	1	
8	Decision - Unanimous	Karl Roberson	Jack Marshman	1	1	2	3	15	16	
8	Decision - Unanimous	Karl Roberson	Jack Marshman	2	1	0	1	35	10	
8	Decision - Unanimous	Karl Roberson	Jack Marshman	3	1	0	1	40	4	
...	...	...	...	...	...	...	...	...	...	

Note. *An excerpt of the tabulated data showing the part of the data that was used in analysis. The variables are labeled as follows: khnro = identifier of a fight; name_f0/f1 = the names of the fighters; round = the number of round; f0_first_att = binary value denoting if the fighter coded f0 was the first one to hit; first_att_val = the objective categorical value of the first attack (if it hit, missed or was blocked); att_val = the categorical value of the first attack for the fighter coded f0 ('did not hit first', 'missed', 'blocked', or 'hit'); total_str_f0/f1 = the total amounts of strikes for the fighters.*

Leaning on my own amateur experience in both sparring and watching UFC, I determined the first strike of every round of those matches: which fighter attacked first, and if it landed, was blocked, or missed. Only the first strike of the round was analysed in this manner due to time constraints in the data gathering phase. The first strike was determined as the first approach that would have made contact if the opponent didn't move. This was to prevent feints from polluting the data. The whole data had a total of 11 176 strikes, from which 265 were considered first strikes, and the total amount of analyzed rounds was 265. From the first attacks, 103 were misses, 69 were blocked, and 93 landed. Figure 1 shows how the combined total strikes of both fighters in a match were distributed in the first three rounds. Table 2 shows the frequencies of the finishing methods and the types of first attacks.
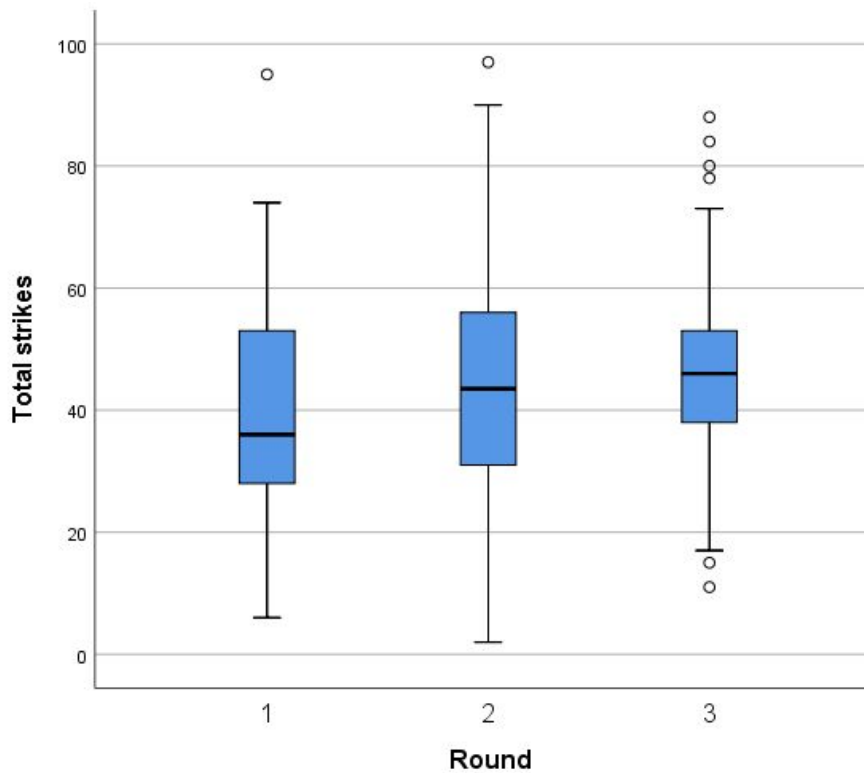
Figure 1. The distribution of the total amount of strikes of the match in the first three rounds.

Table 2

The frequencies of finishing methods and first attacks

	n	%
Method		
Descision	161	60.75
KO/TKO	71	26.79
Submission	33	12.45
First attack		
Missed	103	38.87
Blocked	69	26.04
Hit	93	35.09

Note. The N for both was 265, which was the amount of rounds analyzed.

To determine the overall number of strikes per round per fighter, I used data freely available on fightmetric.com. Fightmetric.com is a site offering extensive data on all the UFC events, including the fighters' statistics (height, weight, reach, stance and date of birth) as well as statistics from their professional career. From the fights, fightmetric.com offers the total amounts of both attempted and landed strikes and the

strike percentages of each fighter, which are further divided into landed strikes per target (head, body, or leg). From ground fighting, fightmetric.com offers the number of attempted and successful takedowns, guard passes and reversals, as well as the percentage of successful takedown attempts. All statistics are available for both the whole match and per round. For gathering the data, an automatic crawler built specifically for this purpose was used, which recursively went through the links, gathering the fight data from each page, and inserted them in a .csv file. The .csv file was later converted into a spreadsheet for cleaning up the data. I then matched the Fightmetric.com data to the video data by reference to the event name, and inside the event, by reference to the pair of fighters' names.

Because one match consisted of multiple rounds, and the number of rounds per match varied, I used a series of linear mixed models for analysis. This was because they deal better with data with missing values in the repeated measures than more convenient models. With this I applied a type III Anova with Satterthwaite's method. The numerical fight identifier I treated as a random factor, with varying intercepts but fixed slope.

For running the statistical analyses I used the programming language R 3.5.2 (R Core Team, 2018) with RStudio version 1.2.5033 and the lme4 package (Bates et al 2015), which is made for fitting linear and generalized linear mixed-effects models.

2.2 The Independent Variables

I will call the fighter committing the first attack "first fighter", and the fighter receiving the attack "second fighter". The independent variables were (1) the number of round, and (2) the type of response to the first attack of the round. The number of round was a repeated measure. The fights had one to three rounds; a round was cut short if there was a K.O., a T.K.O. or a submission, and if this happened on the first or second round, no further rounds were fought. As a result, the amount of rounds varied from one to three per fight, values ranging from 1 to 3.

The type of response to the first attack was a categorical variable described as *missed, blocked, or landed*, depending on if the second fighter avoided the attack, blocked the attack, or received it without either attempting or succeeding in blocking

it. Both of the independent variables were fixed, i. e. their levels were not sampled randomly, but all the possible levels of the variables were included.

2.3 The Dependent Variable

The purpose of the study was to find out if the reaction to the first strike of the round affected the amount of strikes by the fighter in that round. From the total number of landed strikes by both fighters I calculated a strike percentage, which showed who commited what percentage of all strikes struck during the round out of 100 % - in other words, which fighter hit more. The equation I used to calculate this can be seen below (1).

$$\text{total SP of first fighter} = \frac{\text{total strikes of first fighter}}{\text{total strikes of first fighter} + \text{total strikes of second fighter}} \quad (1)$$

Instead of the total number of strikes I used this strike percentage (SP) of the first fighter, which was a discrete ratio, as the dependent variable. This is because how much a given fighter strikes is influenced by three things: (1) how much the fighter tends to strike in general, (2) how much his or her opponent tends to strike in general and (3) the pace of the fight between the particular fighters, which is mostly but not entirely determined by the first two points. Relying only on the amount of strikes by one fighter does not necessarily tell us anything about the fighter in that particular fight, and it does not tell us anything at all about the amount of strikes by the opponent. The data was more normally distributed with the strike percentage than with the total number of strikes.

3 Results

Table 3 shows the mean, standard deviation and variance for total strikes per round for the first fighter, the second fighter, and both combined.

Table 3

Mean, standard deviation, variance and range for the total strikes per round of the first fighter, the second fighter, and both combined

	Mean	SD	Variance	Range min	Range max
Strikes per round	42.17	18.47	341.03	2	97
First fighter	22.39	13.57	184.10	0	76
Second fighter	19.78	12.72	161.86	0	65

Note. N = 265 (number of rounds).

I fit a series of linear mixed models predicting the total strike percentage of the first fighter based on the second fighter's reaction to the first attack. Since there is no established best practice for obtaining p-values or estimates of effect sizes for linear mixed models, I followed Kuznetsova et al (2017), using a type III ANOVA with Satterthwaite's method for approximating the degrees of freedom for the t and F tests (Table 4). For effect size estimates, I followed the method used by Nakagawa and Schielzeth (2013) to obtain marginal and conditional pseudo R^2 values.

Table 4

Type III Analysis of Variance Table with Satterthwaite's method

	NumDF	F value	Sum Sq	Mean Sq	DenDF	Pr(>F)	
round	2	0.65	0.03	0.01	153.87	0.525	
type of attack	3	2.05	0.13	0.04	194.18	0.108	
round:type of attack	6	1.87	0.24	0.04	183.26	0.089	.

Signif. codes: '***' p < 0.001. '**' p < 0.01. '*' p < 0.05. '.' p < 0.10.
Note. The interaction between the number of the round (round) and the type of the first attack (type of attack) is not statistically significant, but suggests a trend in the direction observed in contrasts. The R^2 of the model with only the fixed effects was 0.056, and the R^2 of the full model, with fixed and random effects, was 0.786.

The ANOVA did not reveal any statistically significant results. I used an analysis of contrasts to compare the condition "did not strike first" to the three other conditions, that is, when the first fighter struck first. The contrast was significant (B = -0.21, $p < .04$).

In other words, on the third round, the first fighter hit more if his or her attack was blocked. The model residuals were approximately normally distributed and

heterogeneous, which satisfies the assumptions of linear mixed models. Figure 2 shows the distribution of types of first strikes by round.
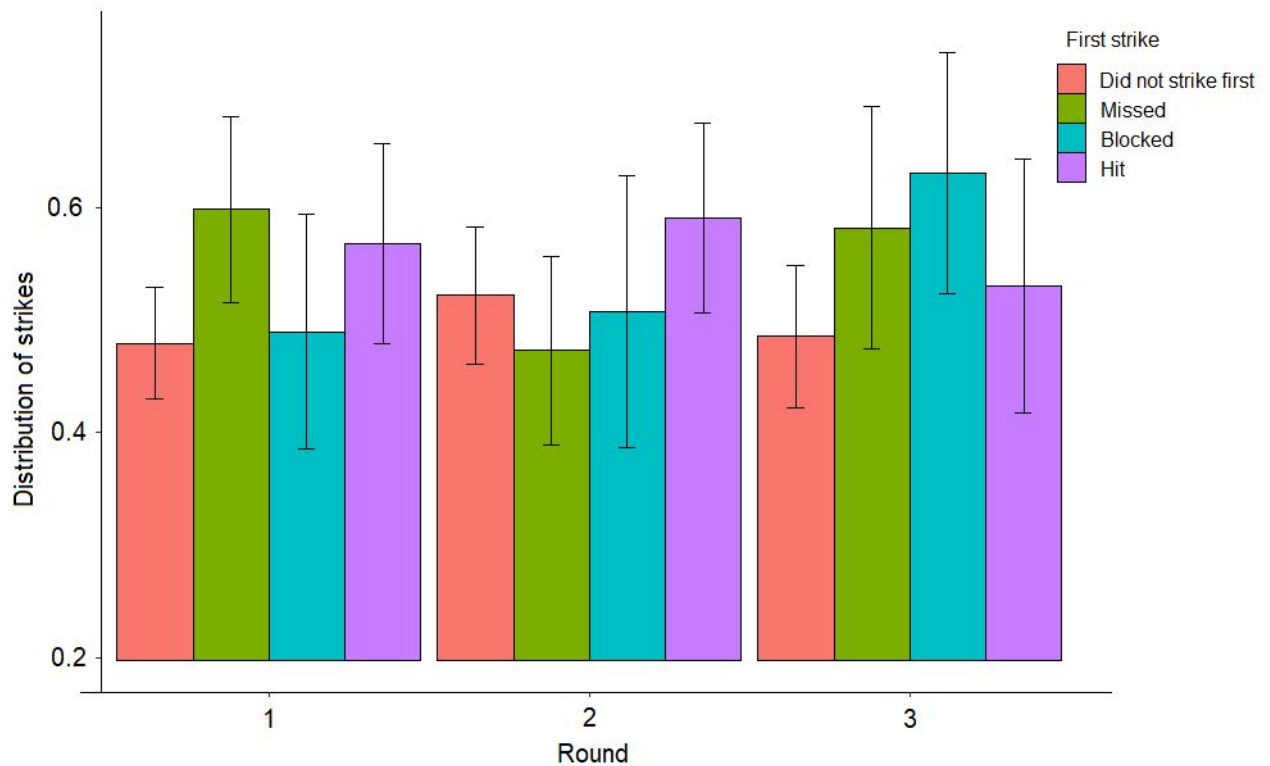

Figure 2. The percentage of strikes (from the total strikes of both fighters) per round attempted by the observed fighter. The error bars have a confidence interval of 95 %. In the third round, if the first attack was blocked, the first fighter hit more.

4 Discussion

4.1 Considerations for Combat Sports

The purpose of the study was to find out if the first strike mattered for the total amount of strikes for either of the fighters in a mixed martial arts match. The data suggests that the first strike does make a slight difference: on the third round, and on the third round only, blocking the first strike led to a higher number of strikes from the blocked fighter.

The finding that the type of reception the first attack gets predicts the amount of strikes for the first fighter only in the third round is curious. A possible explanation could be that in most of the fights, the third round was the final one, and in the five

round format, it was the middle round. If the first fighter was behind on points, hitting more on the third round would make sense. It seems fair to note that for most of the fights analyzed, the third round was the final one, but not for all. From the five round fights, the last two rounds were simply dropped from data instead of dropping the whole fight. This might skew the data, if being on the last round of the fight had any psychological effect on the fighters' behaviour.

The theory of psychological momentum would have predicted a difference between the second fighter's response conditions. After a successful hit that lands on the opponent, the theory would have us expect the hitter to be more successful than his or her opponent. This should mean, in the context of an MMA match, more hitting from the first fighter. In reverse, after an unsuccessful attempt, that either missed or was blocked, the momentum theory would predict a decrease in the first fighter's amount of hitting.

Since no such pattern was recorded on the results, this study fails to demonstrate any kind of positive momentum. However, it does seem to hint towards Silva et al's (1988) negative facilitation. According to Silva et al (1988), an expert contestant who is doing badly in a contest will try to compensate and "make more effort" towards better performance compared to a situation where they would be winning. This is exactly what was observed to happen on the third round, when the first attack was blocked.

The results are also in line with Taylor and Dermick's (1994) theory about professionals being able to harness their downward spirals and turn them into more productive behaviours. However, if that were the case, why doesn't missing with the first strike, which also gives the player no points, also produce more hitting?

An explanation might lie in frustration. According to Dollard's frustration-aggression hypothesis (e. g. Miller 1941) frustration leads to aggression. Missing a target can be a very frustrating experience, as some of the people that have had the opportunity to fight Anderson Silva in the octagon have gone on record to state (Moshkovich, 2013). One of Silva's most known strategies is to use his head movement skills to evade punches with seemingly little effort. Forrest Griffin, for example, stated in an interview that fighting against Silva's evasion game made him feel "stupid" (pearcemark2, 2010).

Based on this, would it not be expected that missing produces more hitting than getting blocked? Since MMA is a game of strategy, getting frustrated or angry does not increase the chances of winning, and since the UFC is on the highest professional level of MMA fighting, this discrepancy could be explained by the expertise of the fighters. If getting frustrated in the cage leads to losing the fight, a successful fighter should learn to control their frustration. This would, as well, be in line with Taylor and Demick's (1994) take on experts' ability to harness downward spirals into a productive force. Unfortunately, even though in reported experience it appears true that hitting *something*, even if it is a block, produces different psychological effects than hitting air, this seems to be a vein of research yet to be explored in the context of martial arts.

The data in this study was somewhat limited, leaving open a lot of room for speculation as to the reasons for the findings. These results do not give much support for the idea of positive psychological momentum, or "hot hand phenomenon", but, as stated before, the methods used do not allow for disproving the phenomenon. As explored above, regarding the different results on hitting a block or missing, the data does not contradict Taylor and Demick's (1994) ideas about experts' ability to avoid downward spirals. But how does the data relate to their wider theory, the Multidimensional Model of Momentum?

Putting the data in terms of the Multidimensional Model of Momentum, could the first attack be assigned as the precipitating event, that is, does it fall within the demands that Taylor and Demick put on the event's salience (1994, p.56)? The first attack in a fight is clear enough, but there is no reason to assume it is dramatic enough to produce a change in the fighters' cognitions. After all, every fight starts with the first attack, and if there is nothing extraordinary in the attack itself, it probably is not precipitating anything. However, a more rigorous analysis on combat sport matches could be used to examine the Multidimensional Model of Momentum more closely. Further studies on striking trends in combat sports might reveal more interesting phenomena in hand to hand combat, and statistical analyses of strike distribution could help further develop the strategies of combat sports. Additionally, more qualitative research on the experiences of the fighters during a bout could at

least open up some veins of research into how, if at all, the experienced momentum appears in hand to hand combat.

In this study I ignored the ground component (i. e. wrestling) of mixed martial arts fights. When studying effective MMA strategies, the ground should be included, since it is in no way a marginal part of the sport. Including guard passes and submission attempts into the analyses of strike percentages should make the data more faithful to the complexity of the sport, and enable a whole new set of possible research questions. For example, do takedown attempts or guard passes interact with the first strike in any meaningful way? Does a fighter who prefers takedowns and wrestling to hitting get more easily discouraged if the opponent lands the first hit, compared to a fighter with a preference for fighting standing up? Is there any relationship between passing the guard and landing strikes? Analyzing the ground game separately, and comparing it to grappling sports like Brazilian jiu jitsu or submission wrestling, could also be of interest - how does hitting affect effective wrestling technique?

4.2 Considerations for Self Defence

There is not a lot of academic research, existing frameworks or definitions for self defence situations. Aggressive behavior as a wider phenomenon has been studied under several different disciplines, and some work has been done on trying to unify the theoretical field (e. g. McEllistrem, 2003; Meloy, 2006). This, however, is still a rather thin basis to build on, and leaves open several questions. For example, at what point does an argument turn into a fight? What distinguishes a fight from a self defence situation? Can there be a self defence situation without a physical altercation? In short, the field of self defence research is murky, loosely defined and volatile to misinterpretation. Where the existing definitions and frameworks are lacking, I try to build crude ones on my own for the sake of discussion. The aim here is to be able to determine what kind of a situation we are talking about.

It is important to note that not all self defence situations are the same. Following McEllistrem's (2003) classification, the type of self defence situation described here arises from *affective violence*, where the aggressive behavior is the

result of the aggressor getting emotional (angry or afraid) from a perceived provocation during what I will refer to as *the escalation period*. As contrast, in *predatory violence*, emotion is minimal, and the ensuing violence is not triggered by the situation itself. All following references to self defence situations should be understood in the context of the former type of violence, and not the latter type, unless otherwise specified.

I base the following on Nurmi and Litmanen's (2018) definitions of self defence in situations where the personal integrity of the victim is violated (fin. "*henkilökohtaista koskemattomuutta loukkaava itsepuolustus*", p. 32). A physical altercation is often preceded by an "escalation period", which can include the aggressor using verbal attacks like threats, approaching the target, and other intimidating behavior (for a comprehensive list, see Nurmi & Litmanen 2018, p. 65). The target can respond to the escalations either by (a) going along and adding to it, escalating the situation further, or (b) trying to de-escalate the situation. If the escalation is mutual, the situation can develop into a physical fight. If the target tries and succeeds in de-escalating the situation, both parties walk away or continue their activities unharmed. If the target tries but does not manage to de-escalate the situation, a physical altercation can ensue, in which case we start to talk about a physical self defence situation.

The time frame in which the *prevention* of a physical altercation has to occur is the escalation period. Even though the escalation period doesn't always lead to a physical altercation, counting that time frame into a category of "self defence" makes sense, if we want to talk about the first physical attack. It also makes sense to consider self defence to include preventing an attack.

The action that separates the escalation period from the physical altercation is the first physical attack - for example, a push, a punch, or a grab. In other words, that is the act that ends the escalation period. In a self defence situation, the first physical attack matters. An action is always quicker than a reaction, and once someone decides to attack, they have the element of surprise on their side. Though the target may have noted that the aggressor might attack soon (the signs can be abundant [p. 61], although they necessarily are not), they will not know what type of attack he or

she will perform, or if he or she has, for example, a firearm or a bladed weapon in their possession.

In the martial arts community, there is a lot of talk about the significance of the first attack both in the combat sports and self defence contexts. Talonen (2013) analyzed video footage of violent encounters, and concluded that "the person who struck first often won or dominated the fight" (p. 33). Talonen speculates that this may have been because of the attacker's aggressive attitude. An important note is that, according to Talonen, reactions to the attack often occurred too late to be useful, even though the situational clues about the imminence of the attack were clear. This is an important point to consider for self defence training of both civilians and professionals: the assumptions about the effect of the initial attack have implications for everything that is done after that. What should the defender do to prevent the attacker from gaining the edge from his or her first attack? Should the defender be the one to hit first?

4.3 Limitations

The decision to use a percentage as a measure instead of the raw numbers was not entirely unproblematic. When studying the hot hand phenomenon in a one on one sport, one must consider both players. In translating the raw numbers to a ratio, some information is lost; a ratio is insensitive to a situation in which the increased hitting of the first fighter makes the second fighter hit more as well. The resulting *slugfest* situation could be seen as both players having a "hot hand". This was considered, but I chose the ratio for two main reasons.

First, due to limited resources, I was not able to establish a baseline for the fighters appearing in the data. For a raw number of strikes during a round or a match to mean anything, and to determine if the fighter was "hot" during the round, there needs to be a baseline showing how much the fighter typically strikes when he or she is not hot.

Second, even if was able to establish a baseline, as the smallest unit of information on the amount of strikes was the total number of strikes per round, it would have been impossible to tell how the strikes were distributed during the round.

For example, the same amount of strikes could have been evenly distributed throughout the round, dealt in bursts when the other fighter was hitting, or dealt in bursts when the other fighter was not hitting. The time allotted did not allow for a more careful play-by-play analysis that I would have required to be able to determine this.

4.4 Conclusion and Further Avenues

This study goes to show that there is a possibility to learn a lot from and about combat sports and self defence alike. Had the data allowed, the current study would have benefited from a more nuanced analysis. Questions like "what happens after a block, and does it differ from a situation after a miss" could be answered, if a chronological play-by-play would be analyzed. In studying the seemingly minute details of MMA matches, there is potential for very interesting findings that can help further the understanding of how the human mind works under tremendous pressure. This can help both the fighters in the octagon and the scholars in the cube.

     Even though the theories on psychological momentum were not much furthered by this study, it is clear that there is a lot to learn about MMA as a sport. Detailed statistical analysis of the fights could help mold the strategies of the fighters, and they could be used to develop the sport further. Research on qualitative aspects of fighting and the mental states required to fight could further both the professional fighter's and everyman's understanding of violence and how to survive (or win) it. Well-framed, methodologically robust studies on MMA could even help shed some new light on the research on violence as a whole - on the unwanted, non consensual violence found on the streets and behind closed doors. That is, anywhere outside the ring, the dojo, or the octagon. The statistics of when and in which situations someone is more likely to hit more (or less) are important information for both the professional fighter and the person wishing not to get hit, and with that kind of information, self-defence coaches could teach better methods for surviving a violent encounter. Qualitative studies on the head space of fearless fighters could help the common person survive in a pinch.

For the self defence community, actual, reliable data on how the first attack affects the results of the situation in the field (or, more commonly, on the streets) is nigh impossible to gather: the only third person perspective material available are street fights caught on video, and these are a bit problematic. Fights filmed by a third party might be staged, which would obviously bias the data, or the mere knowledge of the presence of a camera might affect the actions by either of the fighting parties. Although security camera footage is considered "good enough" material, it has its limitations that cannot be overcome with current methods or research paradigms.

For these reasons, though the field of self defence research calls for both clear, common frameworks and cleverer research paradigms, it can also be advised and steered by combat sports research such as this study. The combat sports and self defence communities are intertwined, and resources should be pooled to help both fields develop to their greatest potential.

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