
PREDICTING KUMITE STRATEGIES: A QUANTITATIVE APPROACH TO KARATE

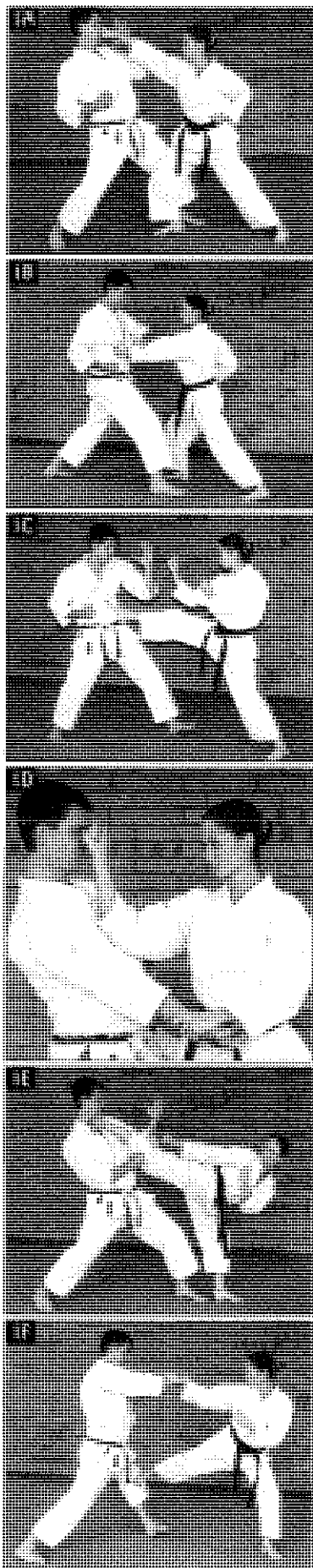
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One of the skills that needs careful development while practicing *kumite* (freestyle fighting) is the understanding of the attacker's body language. This, I believe, requires both individual learning to "predict" the attacker's intentions as well as teamwork to observe and analyze *kumite* performed by others. The main goal in this case should be to dissect the subtle movements that precede a kick or a punch. We all know that no matter how unique an attacker may be, his *kumite* becomes predictable after sparring with him for a few times. Likewise, there are general behavioral patterns applied to humans which can help us anticipate when an individual is about to attack without having to necessarily experience a previous fight with the individual in question. This idea is by no means new. Boxers, martial arts competitors, full-contact fighters, and even the "ultimate" fighters (who brake each other's bones at the Octagon) spend hours studying videos and trying to predict how future opponents will fight. This is as crucial in sparring as it is in understanding the fighting characteristics of the human body. Let's examine a few cases.

Professional boxers study how to anticipate the combination of punches that an opponent may perform by looking at subtle changes in the opponent's facial expressions. Apparently, there is some correlation between facial gestures and body movement. When a fighter lowers the chin to the side and closes the lips tightly there are high probabilities that a "hook punch" will be released from that side of the body (i.e. chin moving down to the left could mean that a punch is coming from the left). This may not be entirely surprising to someone with karate experience, since we know that, for example, a slight lifting or lowering of a shoulder implies that a front kick (*mae-geri*) may be coming from that side of the body. Some "readable" body traits that usually occur before, during, and after fighting include: increased breathing rate, flushed face (adrenaline rush), tense-rigid body, shaking (imminent attack), expanded pectorals, small pupils in wide-open-non-blinking eyes, twitching, and clenched fists.

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of G. Paz-y-Miño C.*



Predicting aggressive behavior might be intuitive for most human beings. Life experiences provide us with basic skills to anticipate and avoid some potentially violent scenarios. However, anticipating how a trained fighter will use his mind during kumite requires a more elegant method than simple intuition. Kumite is a ritualized type of behavior which is performed in bouts (repetitive sequences of fighting techniques). It can be measured (i.e. time spent in sparring, number of strikes per minute, or total number of fighting bouts) and, consequently, its patterns can be predicted with some degree of accuracy. It is possible to record sparring sequences (the continuous and connected series of attacks) with a video camera, calculate their frequency of occurrence, and examine whether there are predictable combinations of strikes. The methods discussed here are relatively simple and any reader who has overcome the struggles of learning a karate routine (*kata*) should be able to understand them.

Kumite occurs in stereotyped sequences, which may be the result of a common casual factor (i.e. same block against a particular attack), or of one fighting technique stimulating or priming the next. The following examples illustrate the relative frequency with which certain karate techniques could appear in a fighter's repertoire. I will also discuss how to determine if some techniques occur in a predictable sequence or if certain strategies have a high probability of occurring together. The more frequent two techniques (or combinations of techniques) occur, the higher the probability that they will occur together. However, note that it is unusual for one technique to follow another 100% of the time. Instead, two related techniques may follow one another at some probability level that is less than 100% but higher than random chance.

EXAMPLE 1: KINEMATIC DIAGRAMS AND TRANSITION FREQUENCIES

Kinematic diagrams (Greek, *kinesis* = motion) can be used to illustrate kumite sequences. In a kinematic graph (flow graph), arrows indicate transitions between techniques. An example is:

Straight Punch → Reverse Punch → Front Kick

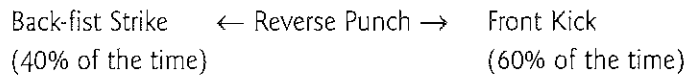
This indicates that a front kick follows a reverse punch, which follows a straight punch (Sequence 1). (This notation is also known as Markov chains.) Transition frequencies are percentages that indicate how frequently one technique follows another. For example, a transition frequency of 60% between a reverse punch and a front kick would indicate that when a reverse punch occurs, in 60% of the cases it will be immediately followed by a front kick. Note that each technique may be followed by more than one other technique.

Sequence 1

Frequent attacks used during kumite:

- A) straight punch, B) reverse punch,
- C) front kick, D) back-fist strike,
- E) side/back thrust kick, F) lower level side kick.

A reverse punch could be followed 60% of the time by a front kick and 40% of the time by a different technique (i.e. back-fist strike). In such cases, two arrows should be drawn from a reverse punch to the other two techniques.



If this is the case, a karate practitioner receiving a reverse punch from this hypothetical opponent should also expect (based on probabilities) to receive either a front kick or a back-fist strike as follow-up attacks. Note that it is also possible that two techniques could follow one another and, in this case, arrows should be drawn in both directions: reverse punch ↔ front kick. When the same technique occurs twice, i.e. a front kick followed by another front kick, a “U” shaped arrow should be drawn indicating that the action repeats itself.

The majority of karatekas practice numerous techniques in a single training session. However, most participants in kumite tournaments are experts on no more than a handful of strategies, which are – of course – used intelligently. Therefore, anticipating how a future opponent will fight is by no means impossible. First, begin by compiling a list of all the individual techniques used by a karateka during kumite training (or tournament participation), as well as their frequencies of occurrence (number of techniques used per unit of time). A videotape camera will be essential in this case. Table 1 offers an example including five techniques.

Table 1

Techniques known or used by a karateka during different kumite sessions. Data corresponds to a total of ten minutes of continuous sparring sessions videotaped during various bouts of kumite. Data rounded to next highest values.

Techniques known or used by a karate practitioner	Number times the Technique was used	F = Frequency of occurrence Number of attacks per minute
Straight/lunge Punch	12 (8%)	1.2 (12÷10)
Reverse Punch	62 (40%)	6.2 (62÷10)
Front Kick	38 (25%)	3.8 (38÷10)
Back-fist Strike	10 (6%)	1.0 (10÷10)
Side Kick	32 (21%)	3.2 (32÷10)
TOTAL (%)	154 (100%)	15.4 (154÷10)

Second, record all the techniques in sequence of occurrence (i.e. straight punch → reverse punch → front kick) per attack and elaborate a Table similar to Table 2 shown on the next page. Note that most karatekas perform brief and explosive attacks with combinations of two (or three, see Example 2) techniques, which reduces the complexity of the analysis.

Third, a kinematic diagram should be elaborated with the transition-frequency values (percentages) summarized in Table 2. Figure 1 shows a graph of this kind.

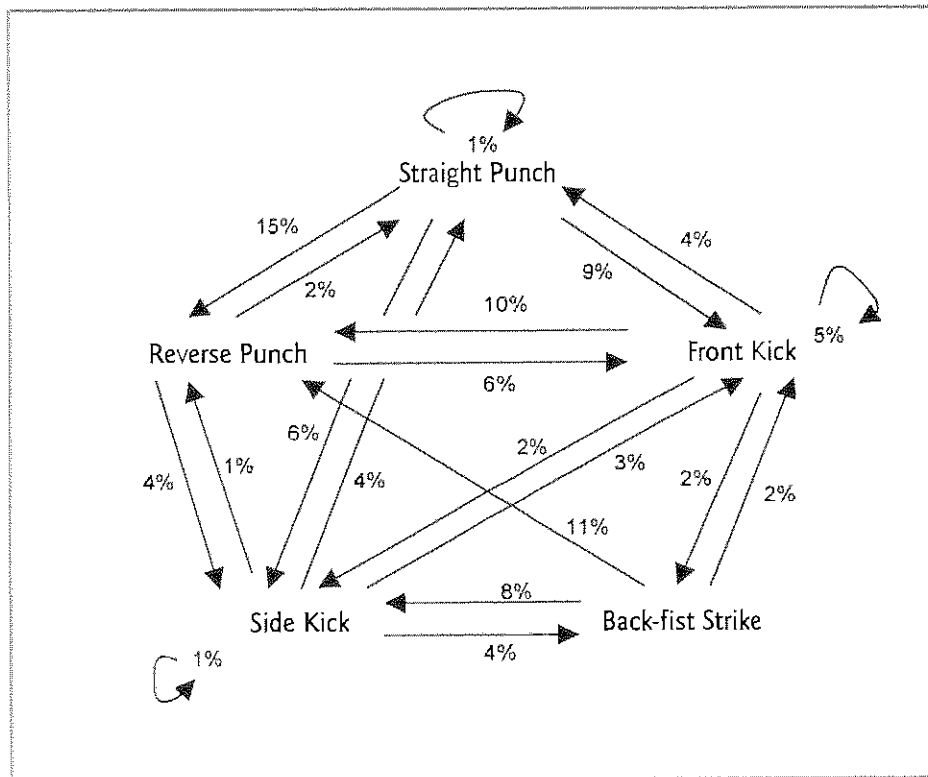
Table 2

Number of times a technique in the left column was followed by other technique. Transition frequencies from one technique to another are expressed as percentages. Data rounded to next highest values.

	Straight Punch	Reverse Strike	Front Kick	Back-fist Strike	Side Kick
Straight Punch	2 (1%)	24 (15%)	14 (9%)	0 (0%)	9 (6%)
Reverse Strike	3 (2%)	0 (0%)	9 (6%)	0 (0%)	6 (4%)
Front Kick	6 (4%)	15 (10%)	7 (5%)	4 (2%)	4 (2%)
Back-fist Strike	0 (0%)	17 (11%)	3 (2%)	0 (0%)	12 (8%)
Side Kick	1 (1%)	6 (4%)	5 (3%)	6 (4%)	1 (1%)
TOTAL (%)	12 (8%)	62 (40%)	38 (25%)	10 (6%)	32 (21%)

Figure 1

Kinematic diagram showing transitions (arrows) and transition frequencies (percentages) among five different karate techniques. Data from Table 2.



Fourth, determine the techniques that occurred with the highest frequency (most common ones). In this case, it is possible to group the data in three different ways:

- ❶ as a percentage of the total number of techniques recorded (i.e. the opponent uses a reverse punch in 40% of his attacks, Tables 1 and 2),
- ❷ as a frequency per unit of time (i.e. 6.2 reverse punch attacks per minute, Table 1), or
- ❸ as a percentage of the total samples (bouts) in which a given technique occurs (i.e. 8 out of 10 different combinations of techniques included at least 1 reverse punch = 80%, data not shown).

These three approaches provide different but complementary information on how to assess fighting strategies. Data presented in Tables 1 and 2 should be carefully studied, as well as the kinematic diagram. Based on this information, we can portray the fighting profile (distinctive signature) of this karateka: He uses a reverse punch, a front kick, and a side kick as his favorite techniques (40, 25, and 21% of the attacks, respectively). During a minute of sparring, we should expect him to throw a reverse punch twice as much times as either kick. And we should expect at least one reverse punch in any of his combinations of attacks.

The kinematic diagram shows how often this fighter connects with a straight punch, a back-fist strike, or a front kick with his most favorite technique, a reverse punch (15, 11, and 10% of the transition frequencies, respectively). It also shows how a front kick and a side kick follow one another in a few cases (2 and 3%, respectively). A straight punch is the technique that initiates most of the attacks, while a back-fist strike is preferably used for connection between attacks. Absence of arrows between techniques (i.e. between a straight punch and a back-fist strike) and unidirectional connections (i.e. between a back-fist strike and a reverse punch) are also possible. Can you hypothesize why?

Finally, the most relevant values summarized in Table 2 (i.e. data for a reverse punch, a front kick, and a side kick) should be analyzed statistically with a simple Chi-square test. This test is designed to assess the degree of correspondence between the real data (observed values reported in Table 2) and the values we should expect if the sequences were the result of random chance (expected values):

$$\text{Expected value} = \frac{\text{Row total} \times \text{Column total}}{\text{Grand TOTAL}}$$

	Reverse Punch	Front Kick	Side Kick	Column Total
Straight Punch	24 (22.1)	14 (13.5)	9 (11.4)	47
Reverse Punch	0 (7.0)	9 (4.3)	6 (3.6)	15
Front Kick	15 (12.2)	7 (7.5)	4 (6.3)	26
Back-fist Strike	17 (15.0)	3 (9.2)	12 (7.8)	32
Side Kick	6 (5.6)	5 (3.5)	1 (2.9)	12
Row Total	62	38	32	Grand TOTAL 132

Table 3

Observed and expected values (in parenthesis) in respect to the number of times a technique in the left column was followed by other technique.

The Chi-square value can be calculated using the equation:

$$X^2 = \sum_{i=1}^k \frac{(\text{Observed value} - \text{Expected value})^2}{\text{Expected value}}$$
$$X^2 = \frac{(24 - 22.1)^2}{22.1} + \frac{(0 - 7.0)^2}{7.0} + \dots = 24.08$$

A high Chi-square value $X^2 = 24.08$ ($df = 2$, $p \leq 0.05$) suggests that our transition frequencies (Table 2) and kinematic diagram (Figure 1) represent a valid prediction about the fighting profile of this karateka. The observed values are significantly different from the expected ones. The reader may realize that the analysis presented in this section could become even more sophisticated if it is applied to triplets of techniques, as shown below.

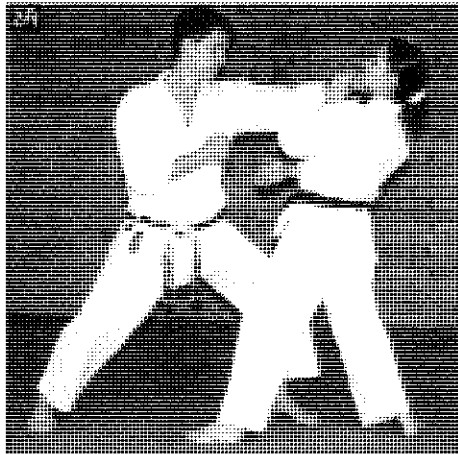
EXAMPLE 2: TRIPLETS OF TECHNIQUES

This example includes additional calculations with the purpose to demonstrate that complex kumite strategies which include three continuous attacks can also be predicted. Relax, do not be afraid of more numbers. If you are able to perform the classical triplet of techniques practiced at any dojo – a straight punch, a reverse punch, and a front kick – you should find this case easy to comprehend.

Any average karate practitioner is capable of designing six different strategies based on these three techniques:

- 1) Straight Punch → Reverse Punch → Front Kick
- 2) Straight Punch → Front Kick → Reverse Punch
- 3) Reverse Punch → Front Kick → Straight Punch
- 4) Reverse Punch → Straight Punch → Front Kick
- 5) Front Kick → Straight Punch → Reverse Punch, and
- 6) Front Kick → Reverse Punch → Straight Punch

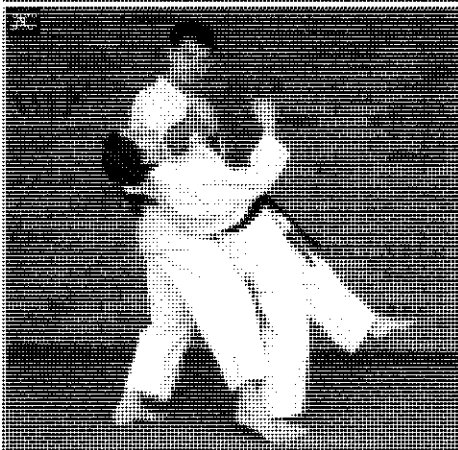
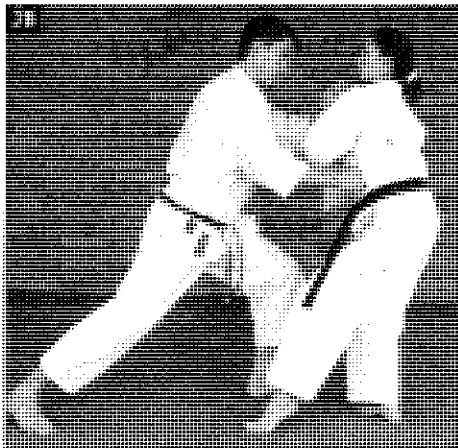
If the karateka in question is limited to use only these six alternatives during a sparring session, it should be expected that he will execute some triplets more frequently than others. The easiest and most comfortable combinations will be performed more often than the most difficult and awkward ones (Sequences 2 & 3). Again, a video tape could help quantify the occurrence of the various triplets. Since every individual is unique and his performance of techniques will follow, in general, a normal distribution (based on the individual's "universe" of knowledge or preference = six techniques), his karate mind will always process information in a distinctive way.



◀ Sequence 2

A classical triplet of attacks designed to surprise the opponent by combining two punches and a sweep/kick to the leg.

- A) upper straight punch to the face,
- B) short-range punch to the stomach,
- C) a vigorous circular sweep to the leg.
- D) This last technique is intended to break the opponent's balance.



◀ Sequence 3

Counter-attack against a direct straight punch to the face. In this case, the defender on the left, performs a very effective triplet consisting of:

- A) change in the trajectory of the attack by blocking with the edge of the hand,
 - B) wrist grab, and
 - C) back-fist strike to the face.
- This triplet can be executed in a fraction of a second.

Interestingly, the number of sparring strategies based on triplet combinations will increase significantly if more than three techniques are incorporated into the karateka's repertoire. How many triplets can a karateka design with ten different techniques in mind? We can calculate this value by applying a simple formula:

$$N_k = N_t \times 2 \left\{ (N_t - 2) + \sum_{a = (N_t - 2) - 1}^n \right\}$$

- Where, N_k = Number of kumite strategies based on a combination of three different techniques (number of triplets)
- N_t = Number of techniques known or used by a karate practitioner (in this case 10)
- $N_k = 10 \times 2 \{ (10 - 2) + \sum [(10 - 2) - 1] + \dots \}$
- $N_k = 20 \{ (8) + [7 + 6 + 5 + 4 + 3 + 2 + 1] \}$
- $N_k = 20 \{ (8) + [28] \}$
- $N_k = 720$

To illustrate the impressive amount of triplet combinations that can be created by any karateka, please refer to Table 4. As the reader may realize, knowing very few techniques is enough to create numerous combinations (something that karate students should keep in mind!).

Table 4

Number of triplet combinations that can be created by a karateka based on the number of techniques known or used by the karate practitioner.

N_t = Number of techniques known or used by a karateka	N_k = Number of triplet combinations that can be created by a karateka
3	6
4	24
8	336
10	720

It is evident that very few fighters will apply 720 different triplets of kumite techniques in their entire karate careers. Memorizing a dozen might be challenging enough for most of us. Therefore, we should expect the vast majority of karate practitioners to focus their training on few effective triplets. Table 5 summarizes frequencies and transition frequencies from one triplet to another. In this case, only five different triplets are shown. The corresponding kinematic diagram for this data is shown in Figure 2.

Table 5

Number of times a triplet in the left column was followed by another triplet. Transition frequencies from one triplet to another are expressed as percentages. Data rounded to next highest values.

Table 5	Straight Punch → Reverse Punch → Front Kick	Front Kick → Straight Punch → Reverse Punch	Straight Punch → Side Kick → Back Kick	Round House Kick → Back-fist Strike → Reverse Punch	Reverse Punch → Front Kick → Back Kick
Straight Punch → Reverse Punch → Front Kick	3 (2%)	9 (6%)	4 (3%)	16 (10%)	10 (6%)
Front Kick → Straight Punch → Reverse Punch	10 (6%)	3 (2%)	8 (5%)	4 (3%)	4 (3%)
Straight Punch → Side Kick → Back Kick	4 (3%)	5 (3%)	2 (1%)	8 (5%)	2 (1%)
Round House Kick → Back-fist strike → Reverse Punch	5 (3%)	12 (7%)	4 (3%)	3 (2%)	4 (3%)
Reverse Punch → Front Kick → Back Kick	8 (5%)	8 (5%)	2 (1%)	16 (10%)	3 (2%)
TOTAL (%)	30 (19%)	37 (23%)	20 (13%)	47 (30%)	23 (15%)

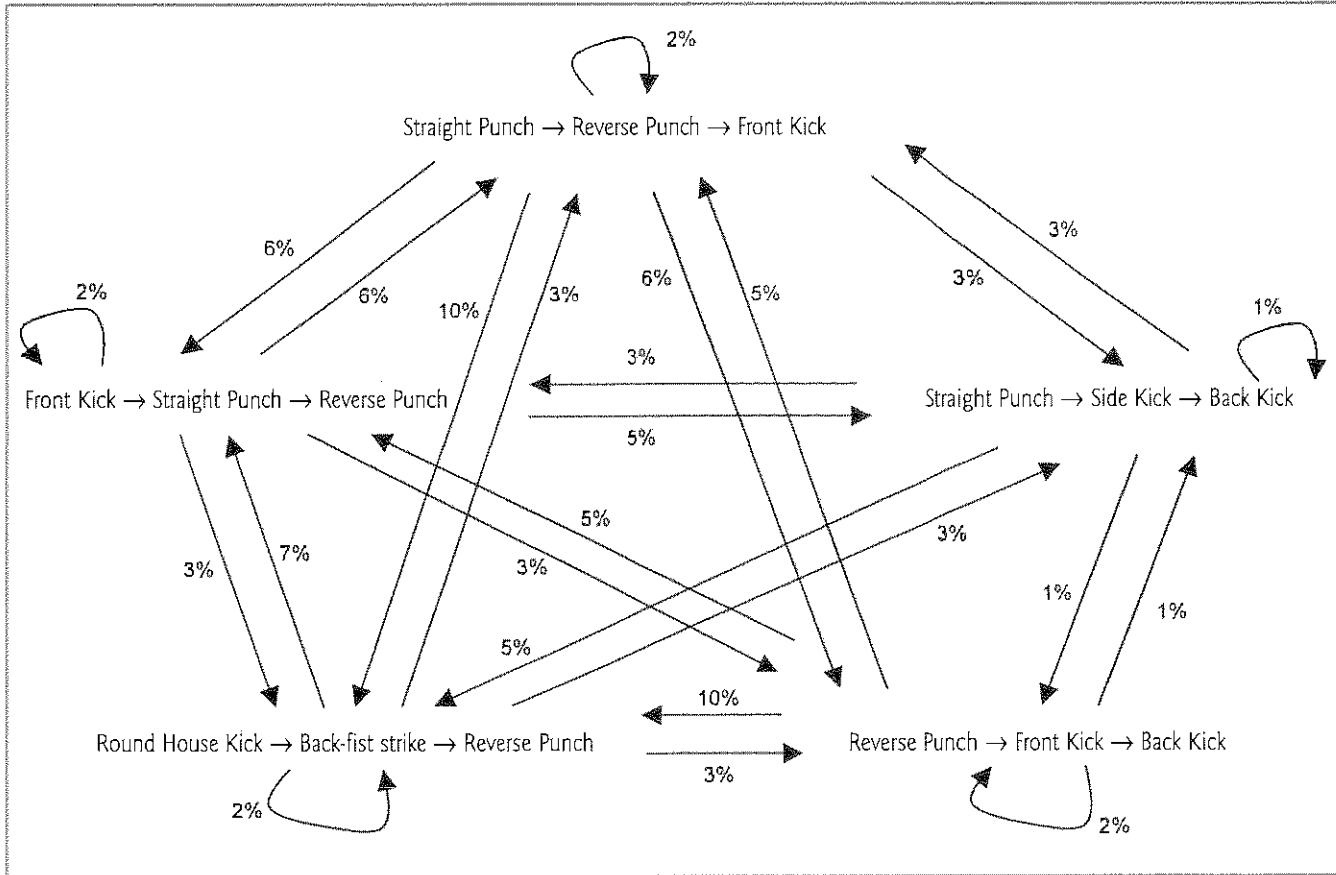
This karateka's favorite triplets are:

- Round House Kick → Back-fist Strike → Reverse Punch (30% of the attacks),
- Front Kick → Straight Punch → Reverse Punch (23% of the attacks), and
- Straight Punch → Reverse Punch → Front Kick (19% of the attacks).

The kinematic diagram suggests that whenever this fighter throws the combination “straight punch → reverse punch → front kick”, he immediately follows up with the triplet “round house kick → back-fist strike → reverse punch” (10% of the follow up attacks). Similarly, when he uses the attack “reverse punch → front kick → back kick”, the follow-up triplet is “round house kick → back-fist strike → reverse punch” (10%). This attacker tends to finish most of his explosive triplets with a reverse punch or a front kick (Table 5). Do you see why?

Figure 2

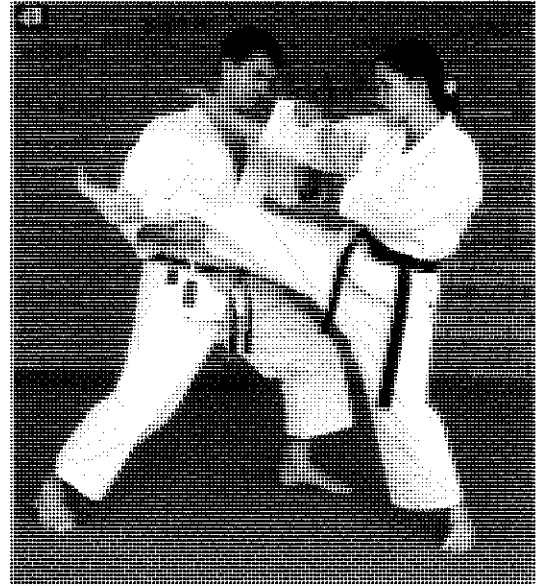
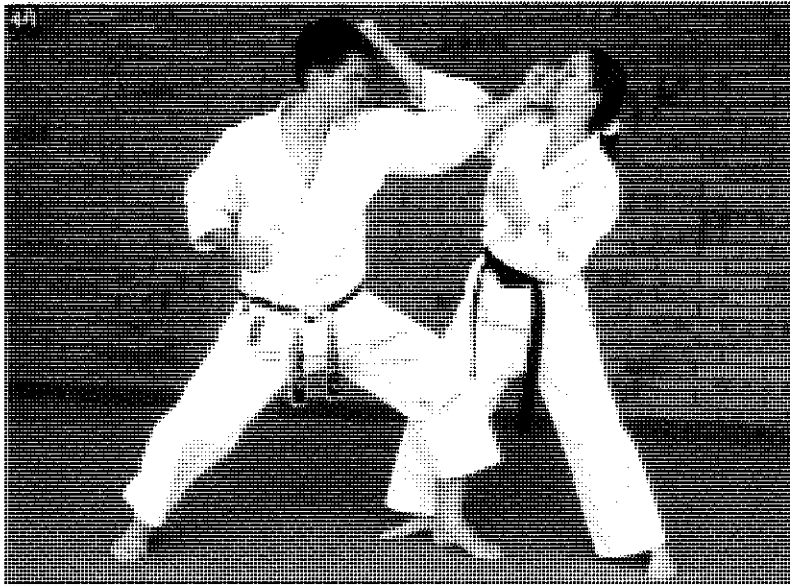
Kinematic diagram showing transitions (arrows) and transition frequencies (percentages) among five different triplets of karate techniques. Data from Table 5.



Finally, the most relevant values summarized in Table 5 (i.e. data for round house kick → back-fist strike → reverse punch; front kick → straight punch → reverse punch; and straight punch → reverse punch → front kick) can now be analyzed statistically with a Chi-square test (same as above). Here are the results: $X^2 = 23.3$ ($df = 2$, $p \leq 0.05$). Therefore, the transition frequencies (Table 5) and kinematic diagram (Figure 2) represent a valid prediction about the fighting profile of this karateka. The observed values are significantly different from the expected ones (analysis not shown).

CONCLUDING REMARKS

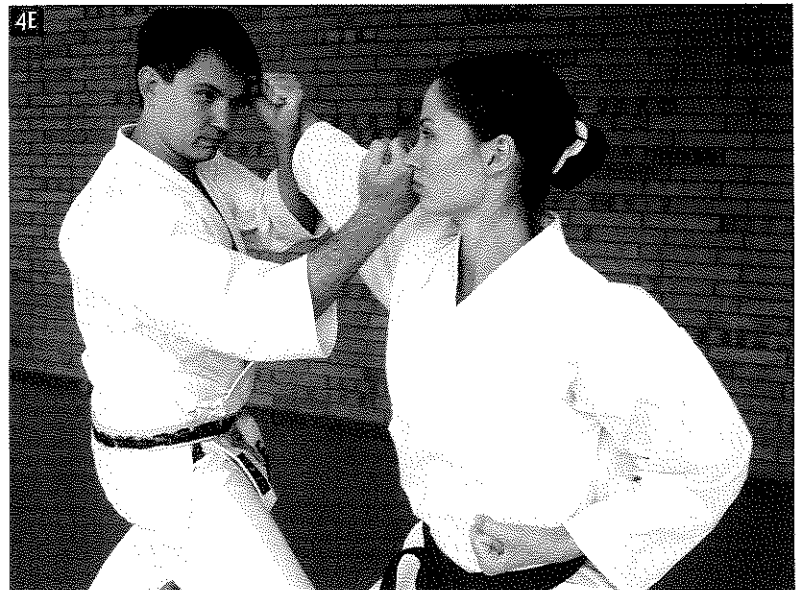
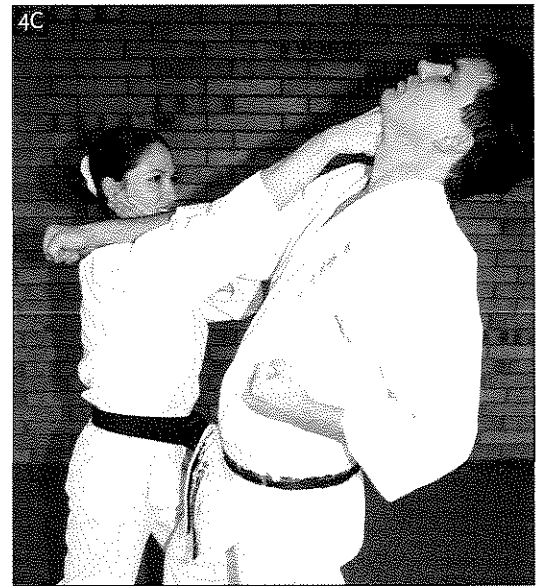
The reader may notice that kinematic diagrams can be drawn for fighting strategies that include single techniques, as well as combinations of any number of techniques (Examples 1 and 2 together). When listing the strategies on a table, what is important is to separate the attacks into distinguishable units (bouts of fighting behavior). Sometimes, the strategy may be a single front kick (the bout will be equal to one technique and that will be all!). In other cases, the bout may consist of a pair, a triplet, or a quartet of techniques in a sequence. Even blocks and shifting movements of the entire body can be included in the analysis (Sequence 4).



Sequence 4

Some single techniques are very effective during kumite, particularly when performed with confidence and explosive motion.

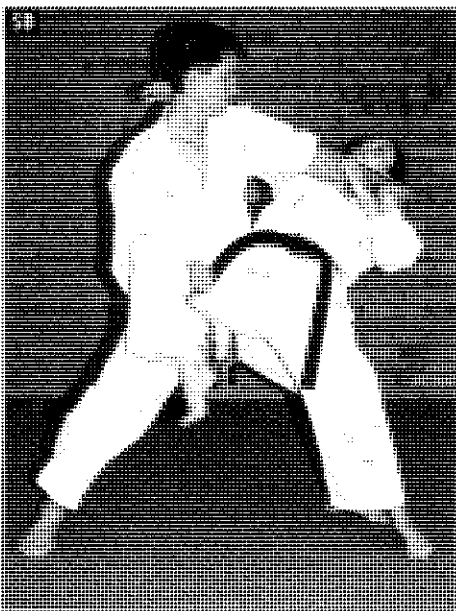
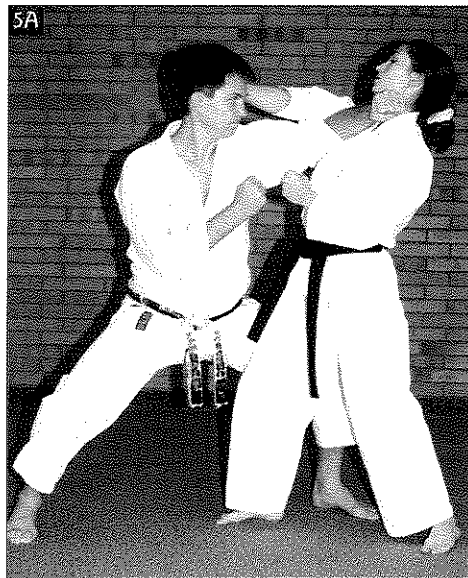
- A) A "hybrid" technique against a direct punch. In this case, a rising-block is simultaneously combined with a back fist to the face; timing is perfect.
- B) Prompt block of a front kick with a scooping block (*suki-uke*); the attacker is ready to be thrown.
- C) Beautiful block of a punch and immediate counter-attack in close range with a reverse punch to the chin.
- D) Similar counter-attack, but in this case with a "hook" punch.
- E) Double combination at close range. Hooking block (*kake-uke*) is executed at the same time that a back-fist strike reaches the face.



Sequence 5

Application of karate series for demonstration and teaching purposes only.

- A) Strong rising block aimed to stop the attacker while the defender enters into the attacker's individual space.
- B) Inertia puts the attacker in a vulnerable position, ready for a
- C-D) throw, or a back break.



In the examples discussed above, it has been assumed that a karateka's own fighting behavior is his primary source of stimulation for sequences of attacks or combinations of attacks (intra-individual sequences). That is, the fighting behavior of the opponent has been disregarded as an important variable. That decision is usually a subjective one left to the experience and discretion of who conducts the observations and analyses. It is evident that important stimuli may be originated from the opponent (inter-individual sequences), a situa-

tion that loosely could be described as "kumite communication" (which some readers may well argue about). Under those conditions, it is possible to cast the data into a table known as a sociometric matrix. As with the intra-individual analysis discussed earlier, associations found between an attacker's behavior and a receiver's behavior are only that, associations. No casual relationship is explicitly demonstrated, although it is implied when the terms *nage* (transmitter) and *uke* (receiver) are used. This, however, will be the subject of a future article.

The value of kinematic graphs and transition frequencies is that they not only provide us with experimental methods to measure karate (or any fighting art) and develop testable hypotheses about it, but also that they give us alternatives for training and teaching (Sequence 5). Anyone could be the target of this kind of analysis based on the association of variables (different techniques subject to numerous interactions). And any instructor could explore multiple kumite and solo practice scenarios based on just a few techniques. The intellectual challenge for a karate practitioner should be to develop creative strategies for kumite and solo practice and, at the same time, make these strategies not too evident for others. A difficult task, indeed!

The readable and detectable body language that helps us predict some of the "attacker's intentions" should continue to be studied in our every day dojo training. Developing "good instincts" is always essential for karate improvement. However, mental strategies – usually undetectable by our common senses – can only be revealed with a probabilistic and mathematical assessment. It is obvious that a karate practitioner confronted with different fighters may perform different strategies, adapting himself to the challenges imposed by diverse stimuli (above). Nonetheless, his distinct individuality will remain detectable, measurable, and therefore predictable.

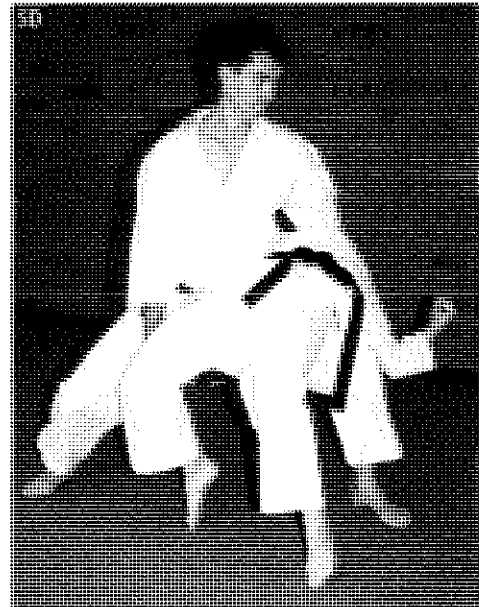
If karate is to become an Olympic sport, kumite will be fought not only on the mat, but also in the laboratory where sport science will take over the strategic planning of sparring. A collection of videotapes could help us docu-

ment and scientifically measure the chronological drifting in kumite strategies of particular athletes, and even of karate schools that have unique ways of preparing their students for combat. Kinematic diagrams and transition frequencies may well be just a couple of methods, among many others, to quantify kumite. Consequently, our sophisticated analysis of kumite in particular – and of martial arts in general – may be only limited by the martial artist's imagination.



GLOSSARY

- Gyaku-zuki*: reverse punch.
Kumite: sparring.
Mae-geri: front kick.
Mawashi-geri: round house kick.
Nage: person who transmits the technique.
Oi-zuki: straight/lunge punch.
Uke: blocking; person who receives the technique.
Uraken (Uraken-uchi): back-fist strike, also called *riken-zuki*.
Ushiro-geri: back kick.
Yoko-geri: side kick.



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