

# Measurement of the Distance at which a Defender Feels Pressure in One-on-One Situations - the Relation with the Theory of the Personal Space -

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The distance between players in soccer games is very important. Many instruction books refer to this concept as "Comfort Space." These indications are based on empirical rule. However, actual distance of the space has never been measured and there is no theoretical explanation. In this paper, we measured the Comfort Space between attackers dribbling the ball and defenders marking the attackers. Subjects were 14 intermediate level members of the university soccer team. The defender who was standing at the corner of penalty area made a signal to indicate when he felt the need to respond to the attacker. At that moment, the distance between players was measured using video images.

Average distance measured was approximately 6m, and the results of measurement indicated that the five defenders who preferred a significantly greater Comfort Space compared to other players also demonstrated higher defensive ability than their teammates. The relevancy of the measured distance and the theory of the personal space were discussed.

**Keywords:** Soccer, Interpersonal distance, Personal space

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## 1. Introduction

In goal-type (open-skill type) ball games such as basketball and soccer, in which offense and defense compete against each other within a defined space, distance between players is an important factor. Such distance can be classified largely into distance between players on the same team, and distance from opposition team players. It is especially important for a defender to control distance from the opponents he marks during a game. This distance differs depending on whether the opponent is or is not in possession of the ball, as well as on the location of the play zone. In instruction books this distance is often referred to as "Comfort Space" (Nissan F. C. Yokohama Marinos ed. 1994; Japan Football Association ed. 2002; Morishima ed. 2010).

Control of the Comfort Space is of extreme importance. For attackers, for example, shorter distance between teammates increases the accuracy of passes. When an attacker closes in on an opponent in possession of the ball, accurate ball control is

required. If passes or traps deviate slightly from the intended direction, the ball may be intercepted by a player on the opposing team. If the distance between offensive players becomes greater, on the other hand, passing distance also increases, and this has an adverse effect on accuracy. In such cases, however, the distance from opponent defenders is also greater; therefore, even if the passes or traps deviate slightly from the intended direction, it may not affect the performance significantly.

Players on the pitch are required to maintain the appropriate distance from other players. As Hughes (1990) stated, for example, that 2m is a desirable distance for the defense side to maintain, the distance between players is often an issue in soccer. However, while this is a result of experience in games, it has not been proven by measurement or explained theoretically.

In this study, therefore, we measured the space between attackers dribbling the ball and defenders marking the attackers in instances where measurement was relatively easy. We evaluated the

distance at which a defender feels “pressure,” which is defined as the moment at which a defender feels the need to take action against an attacker, to clarify the relationship between this distance, the tendency of the subjects (defensive or offensive), years of experience, and peer evaluation.

The mechanism that influences the distance between players observed during games is similar to that which influences the distance we maintain from others during our daily life. The mechanism operates to ensure what is commonly referred to as personal space. The similarity is seen in the tendency of skillful players to prevent attackers from breaking through in one-on-one situations by maintaining sufficient comfort space. Yoshikawa (2012) suggested the potential application of this concept to sports. This study was carried out to evaluate the potential for application. Although many studies on personal space have been published, there are no studies evaluating situations in sports. Therefore, we obtained data to examine correlation with personal space.

## 2. Method

### 2.1. Subjects

Subjects were 14 intermediate-level members of the university male soccer team whose dominant foot was the right foot. Mean age was  $20.3 \pm 0.9$ . All subjects had greater than 10 years’ experience playing soccer, with mean years of experience being  $11.8 \pm 2.1$ . We explained the purpose of the experiment in advance and obtained consent for participation in the experiment. We also surveyed subjects about years’ experience, favorite position, etc.

### 2.2. Questionnaire

We conducted a questionnaire following the experiment to obtain information on the subjects. Questionnaire items included name, age, current position, positions played in the past and the number of years of experience playing in the positions, best or favorite position (FW, MF, or DF), and number of years of soccer experience. We also asked subjects to provide a written comparison of their performance in this experiment and actual games, their performance in the experiment, their defense priorities in one-on-one situations, game performance during high school, and experience as a regular or non-regular player

during high school.

The position they indicated as their best or favorite position in this questionnaire was considered to be their intended position.

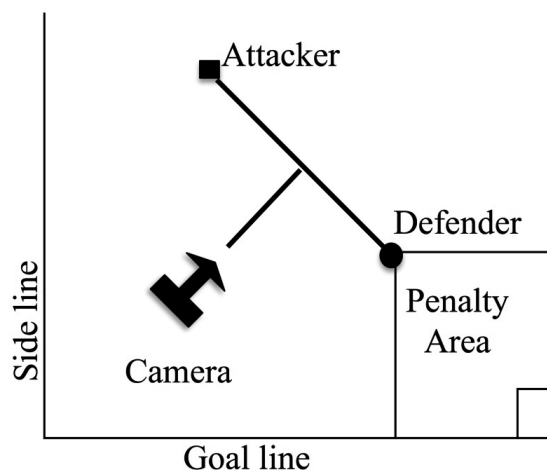
### 2.3. Experiment methods

Experiment items are shown in **Figure 1**. We drew a line at a 45 degree angle from an extension drawn from a corner in the penalty area, and positioned one attacker (FW) and one defender (DF) 10 m apart on the line. We set a video camera (SONY DCR-SR300, 30fps), and recorded calibration markers placed at 1m intervals on the additional line. The experiment started when the attacker began dribbling a ball toward the defender. The defender positioned at the corner of the penalty area was asked to drop his up-held hand as a sign to indicate when he felt the need to respond to the attacker.

### 2.4. Measurement method

We extracted the scenes in which the defender gave the sign from the recorded images (30fps), and measured the distance between attacker and defender in each scene on a computer screen. We placed a point on the middle of the upper waistbands of the attacker and defender on the screen, and calculated the distance between the two points utilizing script based on a numerical calculation program (Python 2.7).

Defender hand movement showing the sign was slight, which caused concern about potential error in the selection the specific frames on which movement was recorded. To address this concern, we created a



**Figure 1** Set up position for experiment

video file of 10 attempts, and asked two individuals with experience playing soccer to identify the scenes. The mean error was 1.16 frames, which we converted into distance. Using the mean dribbling speed of attackers (2.7m/sec), the converted distance was 10.4cm. This meant that a measurement error for Comfort Space of approximately 11cm because one point used for the measurement was approximately 0.85cm on the screen.

## 2.5. Experiment procedures

The experiment was conducted at the soccer field at H University on September 18, 2012. We chose three attackers from among the regular players. Attackers were asked to dribble from the starting point toward defenders along the additional line at the same slow speed used for warm-up. The other 11 players became defenders and were asked to indicate when they felt the need to respond to the attackers by giving a signal with their hand.

Each defender was approached four times to each attacker. When one of the attackers become a defender, we replaced with another attacker, and measurement of each of three attackers was conducted one by one. Excluding mistakes in the number of attempts and failure of measurement due to image problems, the total number of attempts used as data was 158, including 12 attempts by 10 players, 11 attempts by one player, and nine attempts by three players.

## 2.6. Evaluation of Subject Abilities

In order to evaluate the possibility that the distance at which each defender feels the need to respond to an attacker may differ depending on ability, we evaluated subject ability. Offensive ability in one-on-one situations, positioning in offence, defensive ability in one-on-one situations, positioning in defense, and judgment were evaluated utilizing the ranking method developed by Fumoto & Kamata (1999).

We asked each subject to evaluate their teammates on specific skills, classify them into three relatively even groups ("Excellent," "Above average", "Average"), and rank them within each group (teammate evaluation). We determined the ranking of each ability by adding all the scores assigned by all subjects. The lower the total score is, the higher the rank becomes.

## 3. Results

### 3.1. Differences by intended positions

We asked subjects to indicate their desire to be DF, MF, or FW. Five indicated DF, seven indicated MF, and two indicated FW. Calculating mean distance from attackers, subjects were classified into three groups (9 to 12 attempts for each subject), subjects who chose DF maintained a 10% greater distance from opponents compared with subjects who chose MF and FW. Since only two subjects chose FW, we compared the differences between the subjects who chose FW and MF and subjects who chose DF (t-test). This yielded significant difference (**Figure 2**;  $t=2.31$ ,  $df=12$ ,  $p<0.05$ ).

### 3.2. Difference by years' experience

We divided subjects into Group A ( $n=4$ ), whose years' experience was greater than the average, and Group B ( $n=10$ ), whose years' experience was less than the average. The distance from attackers preferred by Group A was 0.6% less than Group B; and the median value was 2.7% greater than Group B (**Table 1**). However, t-test conducted to compare the difference in means yielded no significant difference.

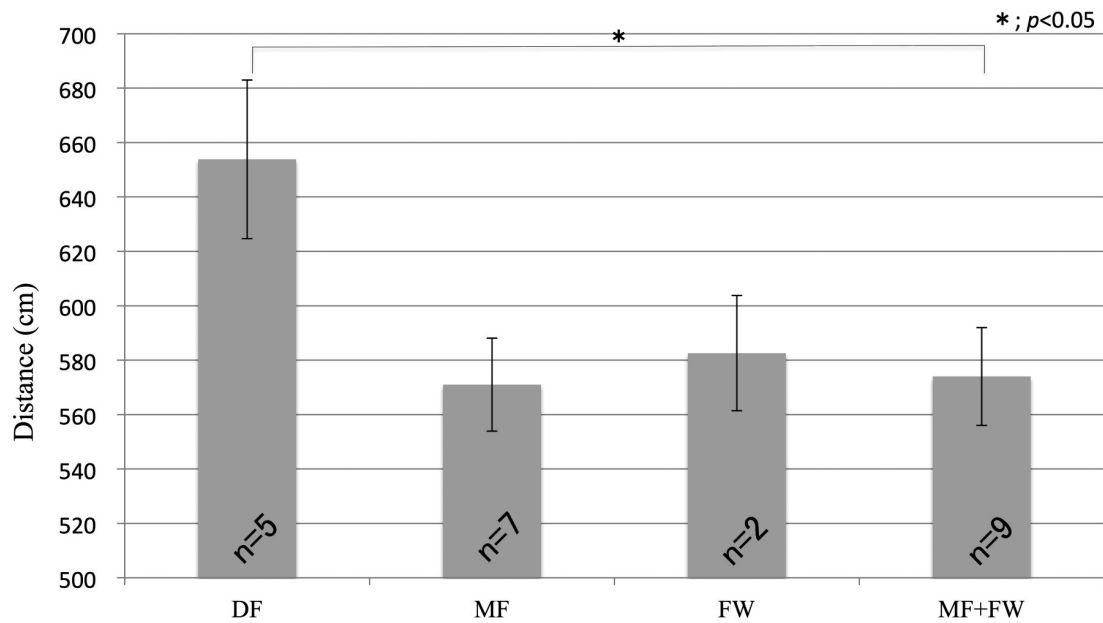
### 3.3. Difference in abilities by teammate evaluation

We divided 14 subjects into upper and lower groups based on the evaluations of five skills. Each group had seven subjects. **Table 2** shows the results of mean values for distance from attackers obtained from the two groups. We conducted t-test to compare the two groups. The skills that revealed significant difference between the upper and lower groups were positioning in defense ( $t=2.52$ ,  $df=12$ ,  $p<0.05$ ) and defense in one-on-one situations ( $t=2.52$ ,  $df=12$ ,  $p<0.05$ ). However, the upper and lower groups classified by these two aspects were, coincidentally, the same subjects in this study.

## 4. Discussion

### 4.1. Changes in measurement depending on attacker

Attackers in this study were all players on a same



**Figure 2** Distance that the defender maintains from the attacker according to playing position

**Table 1** Distance that the defender maintains from the attacker according to years' experience

	Distance (cm)		
	Mean	SD	Median
Greater experience than average (n=4)	600	20	601
Less experience than average (n=10)	603	26	585

**Table 2** Distance that the defender maintains from the attacker according to teammate evaluation by skill

Skill	Evaluation	Distance (cm)		
		Mean	SD	Median
Offensive ability in one-on-one	Higher (n=7)	603	30	575
	Lower (n=7)	601	19	605
Positioning in offence	Higher (n=7)	612	30	596
	Lower (n=7)	592	18	595
Defensive ability in one-on-one *	Higher (n=7)	643	31	646
	Lower (n=7)	562	16	566
Positioning in defense *	Higher (n=7)	643	31	646
	Lower (n=7)	562	16	566
Game judgment	Higher (n=7)	627	29	605
	Lower (n=7)	577	21	566

\*;  $p < 0.05$

team; therefore, defenders could be expected to already know the tendencies and running ability of each attacker. Defenders could, therefore, better prepare their responses to individual attackers, which prompted concern about the potential for influence on measurement. In fact, in pretest, some subjects changed distance depending on attacker ability. **Table 3** shows the aggregation of measurements by attacker. Attackers were all excellent in the FW position, and there was no significant difference by attacker, which prompted the conclusion that there was no such impact. Therefore, we included all attempts as data, including those in which attackers became defenders.

#### 4.2. Comparison by intended position

Difference in intended position revealed significant difference at 5% between DF and MF+FW (**Figure 2**). However, only two individuals intended to be FW; therefore, we also combined these with individuals who intended to become MF, which made it difficult to clarify the difference between MF and FW.

We would like to consider the reason that the subjects who intended to become DF preferred significantly greater Comfort Space than those who intended to become other positions. Longer Comfort Space means the ability to quickly perceive the movement of the attacker. The ability to sense the movement of the attacker allows the defender greater time to prepare for the movement. This may have positively influenced the defense. The difference in awareness in responding to attacker movement may have caused the significant difference in Comfort Space before taking action. Therefore, those who intended to become DF are highly motivated to track the attacker's movement, and take quicker and more accurate action.

#### 4.3. Comparison by teammate evaluation on ability and years' experience

Comparison of years' experience playing soccer revealed no significant difference. This may have resulted from the fact that all subjects were university soccer team members with greater than 10 years' soccer experience (Group A average: 14.4 years, Group B average: 11.4 years).

Meanwhile, their abilities and teammate evaluation yielded significant difference at the 5% level between upper and lower groups regarding positioning in defense and defense in one-on-one situations. (However, as described in 3.3., players classified into upper and lower groups regarding these two aspects were, coincidentally, the same.) This means that subjects evaluated as having high ability in defense responded more quickly to attackers. Defenders maintaining greater distance from attackers have more time to respond to attacker movement. Such defenders, therefore, exhibited defense ability that was highly regarded by their teammates. However, we did not confirm that teammates gave high scores because defenders maintained greater distance with the specific intent of having sufficient time to respond to attackers.

#### 4.4. Comparison between intended position and teammate evaluation

Positioning in defense and defense in one-on-one situations are defensive abilities. Mean score regarding these two aspects of defense revealed that all five subjects who intended to become DF were ranked in high in defensive ability.

If we consider intended position as a subjective evaluation, and teammate evaluation as an objective evaluation, the subjective and objective evaluations showed similar results.

The results of this study suggested that subjects

**Table 3** Distance that the defender maintains from the attacker by opponent

Opponent	Distance (cm)		
	Mean	SD	Median
A (n=50)	602	22	596
B (n=49)	614	26	598
C (n=50)	607	45	579



evaluated as having higher defensive ability felt pressure from attackers at greater distances than the subjects evaluated as having lower defensive ability. However, we did not query subjects on this, and could not clarify the reason that subjects with higher defensive ability maintained greater distances.

#### 4.5. Correlation with personal space theory

In regard to personal space theory, the distance at which defenders felt pressure against attackers was approximately 6m, and players with higher defensive ability maintain greater distance. However, the qualitative aspect of the pressure could not be clarified by this study.

Attackers approaching defenders must create pressure. The results showed that subjects who intended to become DF maintained greater distance from attackers than those who intended to become MF and FW. If we assume that subjects who intended to become DF tend to feel greater stress as a result of pressure and risk due to attackers, the personal space may have become greater in relation to this. This is similar to the self-protection theory introduced by Dosey & Meisels (1969), which is an ideal framework for personal space.

A previous study conducted by Dosey & Meisels (1969) showed that individuals with stress require greater personal space than individuals with lower stress. However, subjects in this study were exposed to the same stress, which made it impossible to compare personal space depending on the presence or absence of stress. Furthermore, the previous study set physiological (psychological) limits for invading other's personal space at approximately 40cm; therefore, the results obtained from the previous study were completely different from the results obtained from this study.

However, this was also a non-approaching experiment, as was the previous study, and both examined the recognition of distance in the individuals being approached by others.

As was stated in 4.2., subjects who intended to become DF were aware of attacker movement from a distance, which also indicated that the subjects have greater personal space. Because of the great personal space, said subjects can perceive defenders earlier than those who have less personal space, which enables them to respond to defenders earlier and exercise stable defensive ability. It is considered that

such behaviors regarding defensive ability of subjects were highly regarded by teammates.

The experiment methods in this study were the application of non-approaching experiment used by personal space studies to soccer. The results of the majority of the previous studies that conducted personal space measurement through non-approaching experiments showed slightly less than 2m (Shibuya, 1990; Fujiwara, 1986). These figures are classified into the near phase in social distance (121.9 – 213.4cm) by Hall (1966). Mean values in this experiment were close to the near phase in public distance (365.8 – 762.0cm). Public distance was explained as the distance in which individuals can run away or protect themselves, which matched the characteristics of the figures obtained in this experiment. The 6m value obtained in this experiment is quicker than the actual actions because defenders gave us the sign when they felt the necessity to respond to attackers. This gap may have resulted in greater distance between defenders and attackers. The 2m indicated by Hughes (1990) and the distance acquired from this experiment are essentially different. However, the previous experiment's results approximated the 2m indicated by Hughes (1990). In addition, the 6m acquired by this experiment is also close to the social distance indicated by Hall. These facts suggested that the results acquired through this experiment correlate with the personal space theory.

It is of interest that figures obtained from this experiment are close to the distance in which individuals can run away or protect themselves, which was defined by the personal space theory. Utilizing this theory, it is possible to conduct further research on personal space regarding soccer.

Personal space increases or decreases depending on the relative changes in the level of learning or stimulus (Ihara, 1984). This study showed no significant difference by years' experience in soccer, which indicates that the comparison was carried out among players with similar characteristics only. In order to validate correlation with personal space, it is necessary to compare subjects with different years' experience in soccer and levels of performance. Currently, changes in measured distance through learning have not been clarified. This study did not examine correlation with subject personality or compare with non-approaching experiment with the same subjects outside soccer games. Therefore, direct comparative study of personal space has not

been carried out. This study is only the first step to seeking correlation between personal space in soccer and personal space theory. It is necessary to conduct further research on this matter.

## 5. Conclusion

- Defenders felt pressure from attackers at 6m distance.
- Subject group whose defensive ability was highly regarded by teammates showed greater distance from attackers. This suggested that subjects whose defensive ability was highly regarded were motivated to track attacker movement at a distance, and exercise stable defensive ability.
- Subjects who evaluate themselves as good at DF were also highly regarded in teammate evaluation, the the Comfort Space of said subjects was significantly greater than others.
- The results obtained from this experiment are equivalent to the near phase (365.8 – 762.0cm) in the public distance indicated by Hall (1966). However, the correlation between personal space and distance between players in sports need to be examined further to establish a theory.

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- A Study on Popularization of Alpine Skiing in Japan, *Journal of Aomori University*, 36(3), 177-194, 2014.
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