Meta-cognition as a Tool for Storytelling and Questioning What Design Is

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1. Introduction

People without experiences of designing do not understand what design is. Donald Schon pointed out that this is the hardest paradox and problem in design education [1] ; even though a design teacher, commenting on a student's solution to a design exercise in a school, explains what designing is really and how it should be, the student without any experience of designing so far is unable to understand the real meaning of the teacher's words.

What I mean by "design" or "designing" here is not just limited to what is being educated in design schools, but also include human constructive activities in a broader sense, social or personal, to create things, states or events that do not exist at the moment. Doing scientific researches, producing new social systems, and planning social events are all design acts in social contexts. Personal activities such as changing the layout of one's own room at home and deliberating over coordination of clothes in a way that expresses oneself eloquently are design acts, too. An athlete's exploration about how to move his or her body parts to acquire a targeted embodied skill is also a design act. If people involved in these activities understand "design" better, the world around us, socially and personally, will get better. None of these "designing" activities, however, are exempt from the learning paradox mentioned above. The reality is that it is hard to tell people how to design and what design is ; those who are to design in each domain or context have to embark on designing without knowledge or understanding on what "design" is and should be.

What is it, then, that researches on design are able to do to cope with the learning paradox and hopefully create a future society in which more number of people than now are encouraged to "design" in social or personal contexts and consequently have better understanding of what design is.

First, let's look at what design researches have talked on what design or designing is. Literature on design sketches, such as in Schon [2], Goldschmidt [3], Suwa and Tversky [4], has discussed that finding new features and relations in what

has been externalized so far, e.g. memos, sketches, or mockup models, is one essence of designing. A design theorist Lawson [5] argued that defining new design problems beyond given ones during a design process is one essence of designing. Recent theoretical discussion on design conducted by myself and colleagues [6] has explicated a general structure of "designing" as a cycle of acts of current noema, future noema and noesis ; when solutions to some design goals are provided in the world (acts of noesis), social interactions occur among the solutions, people's lives, and the surrounding situations. Those interactions often generate new social desires and new ways of seeing the world (acts of current noema), which in turn becomes a driving-force to generate new design problems and goals (acts of future noema). Theoretical researches of this sort, although having clarified characteristics of designing acts, do not yet provide insight on how to cope with the learning paradox ; a mere lecture on those characteristics to people, if they are without much experience of designing something, would not suffice to encourage them to "design" their life by themselves.

What, then, could or should we do as researchers? The present paper is to pose a challenging idea that one possible way of contribution of design researches is to provide such fascinating stories on designing acts that encourage people to embark on designing even a tiny aspect of their life. The idea is based on a premise that "what design is" is not something to be taught, but a kind of embodied expertise that people have to acquire through practices of designing in their real life. We believe that motivating people toward practices of designing is what design researches are for.

2. What are "good" stories on design?

What kind of stories on design attract people and motivate them to embark on "designing" in their real life. Typical stories are novels. What kind of novel is evaluated as "good"? First, novels should provide a new perspective of looking at the world, or draw attention to what normally would be unheeded.

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Secondly, if people feel empathy to a novel about the ways in which its characters live their lives, it will be evaluated as good. It is the very second point, we conjecture, that seems to be the key in providing good stories on design.

How should or could we let people feel empathy to stories on design? First, stories should tell what kind of ups and downs were actually undergone during "designing" and how breakthroughs, if any, came to be realized. Those contents will serve as helpful directions and suggestions to newcomers of designing. Secondly, stories should be written as a subjective perspective of a person and about the very process in which he or she "designs" some aspects in his or her real life. The second factor is especially significant ; an objective observation from an outside perspective would not be able to go into the details of something like subjective ups and downs. Stories written on that observation would be hard to let people feel empathy. Stories from the subjective perspective contain many individual aspects and thus are hard to be generalized. However, what people look for in stories is not generalized principles or rules from the objective perspective, but a kind of typicality or empathy they can turn to as they embark on similar attempts by themselves. Therefore, we believe that stories possessing both factors will motivate people to embark on designing and give them directions and suggestions as they undergo designing in their life.

3. Embodied meta-cognition works to provide "good" stories on design

We believe that the methodology of meta-cognition is suitable for providing stories on design, because it is a general and powerful means to see a process from the endo-system view, i. e. internal observation, not objective observation from the outside [6]. If people meta-cognitively feel and externalize, by verbalizing and/or writing memos, what things went on between them and the surroundings and what thoughts and feelings came and went in them, it will provide good basis for stories on a design process.

Meta-cognition is, by its definition, cognition of cognition ; i.e. an act of reflecting on one's own thoughts, perception and movements. What we mean by "reflecting on" consists of two components ; (1) self-awareness of what we think, what we perceive, and how we move our body, and (2) thereby verbalization of them. What, thus, should be verbalized in meta-cognition is :

- what one thinks/thought,
- how one moves/moved body parts and operates on the surrounding environment,
- what one perceives from the environment through five senses, and
- what one senses though the proprioceptive system (as a result of moving body parts).

Since perception and body movements are usually performed without self-awareness, it is almost impossible to verbalize the four kinds of cognition perfectly. Important is, however, that one should make mental efforts to verbalize as much as one can be self-aware of and thereby externalize it as vocal tokens.

We have advocated that meta-cognitive verbalization serves as an effective tool for development of one's own embodied expertise [6, 7, 8]. Why is that? According to the basic notion in ecological psychology (e.g. [9]), detecting variables in own body and the surrounding environment and thereby finding new relations between those variables are the essence of learning of a living creature in the environment. Meta-cognition is a means to observe, from the endo-system viewpoint, the interactions occurring between one's body and the surroundings as mentioned above. One's thoughts and verbalization are part of those interactions. Therefore, meta-cognitive verbalization itself affects the very interactions that occur between one's own body and the surroundings. What does "affecting" mean here? It means that verbalization changes ways in which to think, perceive, and do things to the surroundings, as the notion of situated cognition suggests. This is why, we conjecture, meta-cognitive verbalization promotes detection of new variables and discoveries of the relations among variables. We have accumulated case studies of development of embodied expertise by employing meta-cognition in many domains, which include sports, such as bowling [6] and darts [8], and singing a song [10].

The essence of meta-cognitive activities lies in discovering relations among variables in own body and variables in the surrounding environment. This means, in other words, that what one does through meta-cognitive exploration is to "design" one's own body in a way in which the body fits the surrounding environment. What kinds of variables in one's own body and the surroundings one thinks relevant and what kind of relations one thinks both fit in is the most significant in meta-cognitive exploration. That is the determinant of whether or not one is able to successfully "design" one's body in a way that fits

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the surrounding. The reason why, as I wrote in the introduction, various kinds of human activities ranging from what is being taught in design schools, to scientific or social exploration, to bringing changes in personal daily settings, and to athletes' effort to acquire embodied skills fall onto "design" in a broad sense.

If many people meta-cognitively reflect on the processes of designing in their own contexts, including ups and downs and breakthroughs if any, we design researchers are able to accumulate them as inventories of stories on design.

To be noted in meta-cognitive activities is that the surrounding environment will never be the same, constantly changing. In order for one's attempt of "design" to be successful, one should aim at designing the own body in a way that always fits the changing environment flexibly. Consequently, "design" is inevitably a never-ending story.

We have theorized that meta-cognition is not just a means to externalize and record what is/was experienced in the mind and body, but also more importantly a tool for exploring unsolved problems and discovering so far unheeded relations between the body and the environment. Therefore, people, even if they recognize themselves as amateurs of design, do not have to be pressured that they will have to write "attractive and good" stories that augment the understanding of what design is in reader's minds. The amateur "designers" have only to come to better, even a little, understand what design is after having meta-cognitively reflected on their process and written a story. Readers of these stories do not start from scratch, being motivated by what is told in the previous stories and daring to embark on designing in their own contexts. Consequently, the whole society augment the understanding of what design is little by little.

4. A Story of Meta-cognitive Exploration of Embodied Skills in Sports

This section presents one story of meta-cognitive exploration of batting skills in baseball, a kind of "design" acts, by the author of this article who as a baseball player has undergone ups and downs and finally a breakthrough for the past two years.

4.1. Huge Improvement of Batting Average

Fig.1. shows how my hitting average changed over the past two years, the 2007 and 2008 seasons. The average is calculated as the moving average of latest three games. I played in 17 games in 2007 and 16 games in 2008. The hitting

average in 2007 was 0.103, i.e. 4 hits out of 39 at bats, whereas it was 0.278 in 2008, i.e. 10 hits out of 36 at bats. As you see in Fig.1., the hitting average soared suddenly and remarkably after the end of July, 2008, which is proved by the hitting average for the last three months this year, 0.409, i.e. 9 hits out of 22 at bats. What happened to my body and cognition at the end of July this year? What have I thought and done actually in a custom of meta-cognitive exploration of my batting skills, and how did it lead to the remarkable improvement this summer?
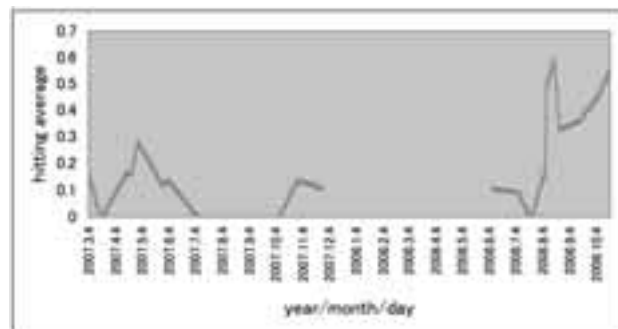

Fig.1. Hitting Average in the 2007 and 2008 seasons
(moving-average over latest 3 games)

4.2. A Custom of Meta-cognitive Exploration of Skills

I began to make it a custom to write what I did, thought and felt by reflecting on my performance meta-cognitively since summer in 2003. Since autumn in 2005 through the end of summer in 2007, I had a coach go to a batting alley together and give advice to me periodically, about once in three months. What we mean by meta-cognitive exploration does not necessarily mean that a learner is supposed to think and do exploration alone. Rather, advice by someone like a coach who has better performance and knowledge becomes significant hints for the learner's finding new variables and thinking of relations among variables, that is, boosting up meta-cognitive activities.

4.3. Meta-cognition lets us know that a drastic change is needed

Here I will write my story, beginning to talk about the 2007 season, because that was the beginning of a long lasting slump ; as you see in Fig.1., it was going to take as much as one year and a half for me to get over the slump. The 2006 season was relatively a good year to me. The average was 0.265, i.e. 9 hits out of 34 at bats, which was the highest hitting average in the team I belonged to. In spite of relative satisfaction, I thought at the end of the 2006 season that I would have to look for a better way to let the timing of my backswing fit the pitcher's motion in the 2007 season. Since I had the coach's

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advice periodically, I have come to do backswing slowly in a way that raises the left leg largely. This revision worked good, leading to the relative success of the 2006 season, but I have come to realize at the same time that my backswing obviously does not fit the quick motion of a few good pitchers. At the very beginning of the 2007 season the struggle for exploring for a better backswing began, which would turn out to last long, for one year and a half.

At that moment there was no proof supporting that I would have to bring a drastic change to the way of backswing. The 2006 season was a relative success, and I could have gone, then, as I did in 2006. But, what I have explored meta-cognitively throughout the 2006 season told me clearly that my body does not fit pitchers who have a quick motion to certain degree. It means, if I use scientific terminology, that my body did not fit the environment when it falls onto a specific pattern. The meta-cognitive recognition of this phenomenon is, generally speaking, a good sign that tells one that one needs a drastic change. If one begins to explore for a drastic change, it will necessarily destroy the current way of using body and lead to a slump. Although being stuck in a slump scares, one has to dare to plunge into it if one really wants to get over the phenomenon of being unable to fit body to some specific patterns of the environment.

4.4. A Period of Groping in the Dark

4.4.1. Back and forth between different thoughts

I thought that the reason the timing of my backswing does not fit to pitchers with quick motion was that I was unable to do a stable backswing. This made me begin to explore a way of stable backswing. One big characteristic of my backswing was to raise the left leg largely, taking ample time. First, for some period, I conceived of and actually tried, in the batting alley, starting backswing by raising both arms a little first, then conveying the motion through the body trunk, and finally raising the left leg, because I thought that backswing is not just a problem of legs and thus I have to use the whole body in a coordinated manner.

Then, for the subsequent period, I changed thoughts, trying to create a rhythm by both legs in a way that makes it easy to find a cue for raising the left leg. Being able to find a proper cue in one's body is highly necessary for moving the whole body easily, naturally, and in a relaxed manner.

Throughout the whole period of groping in the dark, I would repeatedly verbalize onomatopoeia to make the rhythm of my backswing fit to pitcher's motion.

After these periods my thoughts would flip back and forth among these three thoughts different from each other.

4.4.2. Approach to the core of the problem

Soon I realized from the failure in some games that merely creating a stable backswing does not suffice to solve the problem of fitting my backswing to the quick timing of some pitchers. The real problem was, I came to think, that the time I took from the beginning to the completion of backswing was too long. I thought, "Just because I use ample time for the completion of backswing, I cannot fit pitchers with quick motion." On July 12th, 2007, I wrote

"……. Important is how I should put the whole weight on top of the right hip joint without taking much time. If I intend to put my weight on top of the right knee, I guess that it takes more time……"

But, the effort of putting the weight on top of the right hip joint quickly was going to be a failure, neither producing even a stable backswing nor creating a rhythm to make myself fit to pitchers with quick motion.

If I look backward from the current (the 2008 year) perspective, the fact that I conceived of making backswing complete in a quick manner was an approach to the essential core of the problem. But, my solution at that time, i.e. putting weight on top of the right hip joint, was not successful.

4.4.3. Bringing a drastic change in a more fundamental part

A half year went by without any success in exploring a way of making my body fit to pitchers with quick motion. That made me question if raising the left leg largely may be the fatal cause really. I have taken the large motion of the left leg for granted, so this question turned out to be the beginning of a drastic change in a more fundamental part of the body movement.

How large one raises the left leg, generally speaking, depends upon one's innate rhythm of the whole body. Changing it was a big challenge at that time. I had to look for a way of moving the whole body in which the degree of raising the left leg is reduced and the rhythm of the whole body still holds comfortable. Soon I happened to find that rotating the toe of my right foot a little reduces the flexibility of the right hip joint in the initial stance, and that the reduced flexibility not only makes me comfortable even without large raise of the left leg but also enables putting weight on top of the right hip joint quickly.

In spite of comfortableness, however, it turned out in the real game that the new backswing without large raise of the left leg

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could not produce a powerful swing. I came to theorize that the new backswing was to keep the source of the power only around the right hip joint, not using all the parts of the lower body, which should be far from a desirable form.

This way, the 2007 season ended with many trials and failures.

4.5. Meta-cognition serves the role of setting up an antenna for crucial variables

In January, 2008, when I had an opportunity to participate in Mr. Hiroto's workshop on how to use body in sports. He is famous for his book about a *theory* on 4 stances [11]. He theorized from the experience of practicing as a professional trainer that there are typically four types of reasonable stances. His theory amazed me in that I belong to a type, called A 1, and should make the axis of body rotation on the left side separately from the weight position during backswing (i.e. right side). At the workshop I tried to make the rotation axis on the left side of the body, i.e. around the vertical line penetrating through the left hip joint, and quickly had a proprioceptive sense that this way of backswing fits me comfortably. At the same time, I realized that all I did through the 2007 season was to make the rotation axis on the right side of my body. That was the reason why I could not shorten the time taking from the cue of backswing to its completion in a relaxed manner.

"Rotation axis" was a new variable given by him that I had never thought of. In that sense his advice about this variable helped a lot. Based on his advice, I was able to completely grasp the role of the new variable and thereby quickly theorize how I should quickly shift to the completion of backswing and adjust the rhythm of my body to any type of pitchers by keeping the state of backswing stably. At that moment I did not have to raise the left leg largely because I was able to shift quickly to the completion of backswing. All things I had explored so far were then coordinated around "rotation axis on the left side of the body". It was thanks to the meta-cognitive exploration for the past year even without any success that the whole theorization at the instant moment was made possible.

This part of the story suggests that

- meta-cognition serves the role of setting up an antenna to catch the most crucial variables,
- attention to a small number of crucial variables suffices to quickly create a theory of how the whole body should work, if the person is in the custom of meta-cognitive exploration,

- crucial variables depend on persons,
- the proprioceptive sense about the comfortableness of the whole body tells one what are crucial variables for onseself.

4.6. Meta-cognition for refined theorization around a small number of crucial variables

Making the rotation axis on the line penetrating through the left hip joint is "the" crucial variable to me. Although I was quickly able to theorize how I should move my body based on this basic principle, I still had to keep on meta-cognitive exploration to obtain a refined model of how to form backswing and then actually swing, and to find a way to actually control my body to carry it out.

Because I had a serious injury in the waist at the end of January, 2008, and had to spend three months on rehabilitation, it was at the end of April that I started playing in the game. It took three months since then for me to both complete the refined model and find a good way to carry it out in my body. It was at the end of July this year, as I mentioned in the section 4.1, that I finally got out of the long lasting slump and kept the high hitting average, more than 0.400, for the last three months of this season.

The first problem I encountered in games and during practices at the batting alley was the following ; too much attention to making the rotation axis on the left side of the body, i.e. the side of the pitcher, causes stiffness of the usage of the upper body. I set up an aim of removing as much strain of muscles in the upper body as possible. Then, I encountered a book written by Michizo Noguchi [12]. My meta-cognitive antenna caught two notions in the book ; one is that one has to breathe out the air in order to relax, and the other is that one has to stand by bones only without using the strain of muscles in order to relax. This quickly made me notice meta-cognitively that I had breathed in during backswing. I was going to carefully control my breath at bat so that I can clearly breathe out at the timing of backswing. As far as standing by only bones is concerned, I quickly came to realize that I should stand still at bat by focusing attention only to the pit of the stomach, which according to Mr. Hiroto's theory is the most important part for a person belonging to A 1. Since then I was going to explore a better way to remove strains of the upper body during backswing, focusing attention to two things only ; one is to breathe out and the other is to start backswing by shifting the pit of the stomach right downward toward the toe of the right foot,

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where all the weight was put on during the backswing.

A quick completion of backswing that I kept exploring for during the 2007 season in vain is still one of the most important things to be done. Focusing attention only to the way of shifting the pit of the stomach worked well. Further, standing straight with the width of both legs being narrow and without bending knees enabled completing backswing quickly and keeping it for long in a relaxed manner to adjust to any type of pitchers.

Another important variable, I found during the period of refinement, was the movement of the left leg during backswing. As mentioned above, keeping the rotation axis on the left side of the body is a must-do principle. In order to keep it, the left leg necessarily needs to be located far left to compensate the shift of the body trunk (around the pit of the stomach) toward right. This seemed to me a logical conjecture. Since the left leg is near the right one at the initial stance, the left leg should move toward the left side as the body truck shifts right. Consequently the whole body stretches out diagonally from the right top to the left bottom.

This is the end of my story as I went through a long lasting slump, exploring a better way of backswing, and finally experienced a huge breakthrough. This is an act of "designing" my body in a way that fits the surrounding environment of any types.

5. Conclusion

Everybody who has embodied experience of designing in his or her real life understands well that "design" is an endeavor to bring a new perspective to see the world, and that "learning design mind" is to acquire it as embodied experience. However, these are to be learned only through embodied experience, i.e. embarking on a designing act by oneself. It is almost impossible to teach what design is by explaining theoretical notions or the general structure of designing. All that design researches can do is to motivate people toward designing even if they do not have sufficient knowledge about what design is.

We have argued that meta-cognition is useful in two ways in the context of design teaching. First, if design researchers and designers meta-cognitively reflect on their process, they are able to write stories from the perspective of persons as they design, i.e. internal observation from the endo-system view. Just because those stories provide an internal view of the very person who designs, it can possibly motivate amateur people toward designing and give directions as they design. This is a

form of teaching what design is through story-telling, not by conceptual explanation.

Secondly, meta-cognition, due to its innate nature of internal observation that affects interactions between the body and the surrounding, serves as a tool to discover new aspects. If people including designers, researchers and even amateur designers reflect on their design processes meta-cognitively, it will necessarily augment understanding of what design is. Meta-cognition seems to be an effective methodology, too, for questioning what design is.

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