Study on the methods for designing writing tools that consider the ease of writing for various individuals

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With an aim to build a design process responding to an aging society, designers and occupational therapists collaboratively studied the design techniques of writing tools developed for various people.First, we conducted a market research on the writing tools designed user-friendly for various people. As a result, we found that products designed user-friendly for the disabled people tended to be scarce in kinds, expensive, and heavy because of the special shapes. Then, we analyzed and discussed the physical characteristics and the writing motions of the disabled people. We found that even people with severe finger dysfunction could write daily simple letters using general tools and that products categorized under universal design were often evaluated as hard-to-use by the disabled people. As the main factor behind this, it was considered that physical characteristics of the disabled people at the developmental stage were not clarified. Based on these results, we came up with the design conditions of writing tools that would be easy-to-use for various people. In this study, we were able to clarify the various physical characteristics and needs by working collaboratively with occupational therapists and achieved the improvement of efficiency and the accuracy of the development process.

Key words: Universal Design, User-friendly Writing tools,, disabled person,

1. Introduction

As a countermeasure against the Japanese rapidly aging society, there has been worked on barrier-free designs or universal designs. Although products claiming to have a universal design were launched to the market temporary and some of them became generic, many issues such as “lack of know-how and technical information” or “lack of information on ordinary citizen’s needs” were left behind unsolved. It seems that each company is seeking for the way how to tackle on these problems in order to deal with the needs of the times [1].

With these social backgrounds, public test research institutes all over the country have studied human dimension/morphology data and sensorial/motional characteristics and most of which are stored as “numerical data” and used as an important reference for size consideration or evaluation of the products. However, designers need to clarify the various user needs and create a design process to sort out those needs and put them together into a “rational shape” when they work on the development of products. Unless highly-professional, many designers have difficulty in drawing out common conditions from the various capability profiles. For example, they tend to rely on their guesswork in a hearing or questionnaire research, resulting in just putting disconnected personal viewpoints together, as a result of which a problem arises that would require tremendous time and efforts in a statistical research to analyze multiple samples.

Therefore in this study, authors, who are engaged in design development support work for small and medium-sized companies at a public test research institute, have successfully derived design conditions of writing tools designed user-friendly for various people focusing on highly needed writing tools in everyday life as one of the solutions, by working in collaboration with occupational therapists who are specialized in training daily living activity and recovering functions of the disabled people, as well as by clarifying the relationship between finger functions and tools of the people with various upper limb dysfunctions.

2. Research Method and Result

When they are in their childhood or senior years or due to fatigue or change of temperature, anyone feels blunting sensitivity or a decrease in strength and skillfulness in hands [2], which cause even people without disability in their fingers to hold the writing tools in various ways with various writing motions. For example, they tend to talk on the phone taking notes with one hand putting on the memo pad, or write on a counter or a desk that is not adjusted for their height with their postures being distorted [3]. These are often times recognized as transient symptoms or due to old age but not as serious problems. However, they seem to be recognized by the disabled people as serious problems which interfere with them in their daily life.

Therefore, in this study we conducted a research for the disabled people with upper limb dysfunctions in order to grasp the user needs and the market needs of the writing tools in the following way.

First, we collected existing products that were designed user-friendly for various people and conducted a market research of the writing tools.

Then, we selected 10 disabled people with upper limb dysfunctions as monitors and conducted a hearing survey for them to ask what kind of tools they usually used, what were the selection standards, and what kinds products fell under the category of universal design. We comparatively evaluated them with the products collected at the market research, added modification when existing products were not appropriately available, derived the better form of tool suitable for each monitor, and conducted a motion analysis. After checking these research results with each other, we summarized them as the requirements of writing tools designed user-friendly for as many people as possible.

2-1. Market Research

2-1-1. Method of the Market Research

We examined the usefulness of about 1,000 pieces of writing tools ranging from ordinary office supplies to welfare products, by conducting a hearing survey for stationery manufactures or other suppliers and by searching welfare products in the Internet. From among them, we selected about 40 kinds of products that were specified with ergonomic design and/or universal design and/or consideration for the disabled people and examined the characteristics of each product by studying its distribution in the market, price, size, weight, form, and balance of the center of gravity. With regard to the discontinued items, we guessed the usefulness for users by referring to catalogs or literatures and categorized the writing tools mainly into 3 groups (Fig. 1).

2-1-2. Results of Market Research

The following results were obtained:

● The group G, group U, and group W mainly involved products in the general market, products specialized in ergonomic design or universal design, and products in the welfare equipment market, respectively.

● The general market was fully occupied by the group G. As the group shifted from U to W, there was a tendency that the kinds of items became scarce, the average price became higher, and the average weight became heavier.

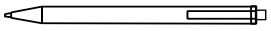
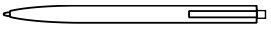
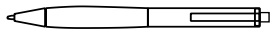
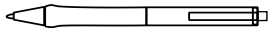
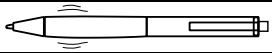
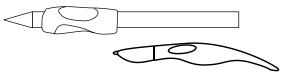
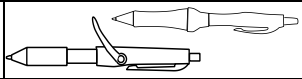
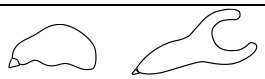
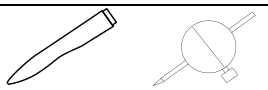
● The shape of the lower grip in the group G was observed with only a bit of variety, while the shape of the upper grip tended to vary e as the group shifted from U to W, which gave off a special impression on appearance.

● Discontinued products launched by major manufactures since 2000 were seen concentrated in the middle segment of the group U.

● The products that were specified with ergonomic design or universal design were evaluated mainly by electromyography for the healthy people during the developmental stage. Whereas few case were categorized and evaluated by physical characteristics even if the disabled people were included [5], [6], [7], and [8].

● The products in the group G had many advantages compared with other groups in that they were easy to store, easy to carry, hard to roll on a desk, and easy to change the cartridge, all of which demonstrated that elements in the usage environment were also important requirements of the user-friendly designed writing tools.

(Table 1: Classification and characteristics of the product in the market)

Group	Classification	Mainly changeable part	Shape	Characteristics	Outer characteristics（excerpts）
G Generic	Generic office supplies ↓ Products applying ergonomic design of the healthy people	Lower grip	Straight	Price-oriented. Products bought by office.	
			Sharp	Integrity moulding with a simple form for giveaways	
			Inflated	Easy to handle with large support face	
			Deflated	Easy to hold the pen tip with large support face	
			Change of material Thick stem	Changeable form along with each finger. Large support face. Causes less pain.	
U Universal	Products to promote ergonomic design of the healthy people and three-point hold ↓ Products with universal design targeting at the diabled people as well	Lower grip ↓ Compound of the lower grip and the upper grip	Triangular cross section/mold	Promotes three-point hold to secure large support face by the three fingers and leads to the finger position to correct the hold.	
		Compound of the lower grip and the upper grip	Various shapes	Large contact area by fingers. Supports the mid point of thumb and the 2nd finger.	
		Compound of the lower grip and the upper grip ↓ Upper grip	Various shapes	Easy to hold with weak strength. Easy to fix by hooking hinger.	
W Welfare	Products in the welfare market mainly targeting at the disabled people ↓ Self-help devices designed for each disability		Various shapes	Easy to hold with weak strength. Easy to write with the motion of arm and shoulder.	
		Upper grip	Various shapes Many of them are substitute type with pen	Easy to write with the motion of arm and shoulder. Operable by parallel movement along a desk. Fixable by attaching to hand.	
			Various shapes Each shape	Applicable to each hand. Originally made by self-help device material	Shape applicable to each hand.

2-2. Monitor Research

2-2-1. Selection of Monitors

In order to analyze the capabilities that can influence the writing such as seated postures, motions of forearm and wrist, finger functions, as well as motions necessary for writing such as a) picking up a tool, b) holding a tool, c) taking out the tip of the pen, and d) writing letters, participants having these physical characters were selected (Table 2).

(Table 2: Monitors' physical characteristics)

Case			Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8	Case 9	Case 10
Disease			Spinocerebellar degeneration	right hemiplegia	Muscular dystrophy	Muscular dystrophy	FOP	RA	Cerebral palsy	Cervical spine injury	Cervical spine injury	Cervical spine injury
Physical characteristics		Seated posture	●	●	▲	▲	▲	●	▲	Support is needed	Support is needed	Support is needed
		Movement of forearm	●	●	●	●	▲	▲	▲	●	●	●
		Movement of hand joints	●	●	●	●	▲	▲	▲	●	●	●
	Hand function	Separated motion	●	●	●	▲	▲	▲	×	×	×	×
		Sensation	●	▲	●	●	●	●	●	×	×	×
		Gripping power (kg)	25	32	1	2	1	0	15	0	0	4
		Pinch strength(kg)	8	9.5	0.5	0.9	2	2	6	6	0	0.5

●：possible ▲：insufficient ×：difficult

2-2-2. Procedure of the Research

● Preparation of tools

We confirmed the writing tools each monitor used in their daily life and the way they hold them, and then the occupational therapists selected several tools from the ones they collected at the market research with which they could stand at a functional position depending on each monitor's physical function. When the existing products were not appropriately available, self-help device materials such as sponge and rubber were used to modify the shape in order to prepare better fitted tools for each participant.

● Method of a hearing survey

A hearing survey was conducted to examine the selection standard for the writing tools they used in their daily life and the way they hold them. All the products categorized under the group U in the market research were surveyed for the monitor's evaluation.

● Analysis of the motions

After adjusting the working posture for the writing motions, the flow of writing letters was confirmed in the order of a) picking up a tool, b) holding a tool, c) taking out the tip of the pen, and d) writing letters and then evaluated using the following method (Table 3). The situation was recorded on video

(Table 3: Evaluation method)

Font size:
- Each individual wrote freely in their favorite size.

Writing pressure (Easiness of exerting strength)
- The number of readable sheets of the invoice of a parcel delivery service (7 sheets) was used to evaluate the writing pressure.

Skillfulness (Beauty of letters):
- Letters on the invoice were evaluated by the individual and the researchers.
- Sentences were created by including basic stipples and strokes that were frequently-used as elements of letters.
  They were evaluated by tracing-writing using letters in big font for easy writing.
  The sentence used for evaluation: "8 回目、あと 1 球。永遠に残るゲームです！"
  "9th inning. 1 more throw. The greatest game in a baseball history! "

Speed:
- Tracing-writing time from the start to the end was recorded.

2-2-3. The Results of the Hearing Survey

Listed in the table below are the writing tools each monitor used in everyday life, the selection standard for the writing tools, and the way to hold them (Table 4).

(1) Writing tools each monitor used in everyday life

Participants in the cases from 1 to 7 used a generic product in the group G.

The participant in the case 8 used a felt-tip marker that wrote well, and the cap of the marker was modified to make it easy to detach by passing a string into the clip on it. She used a mechanical pencil that was similar to the tool positioned in the middle segment of the group U with 4B lead loaded in it. She commented that it would interfere with her life without this pencil since the manufacture had already discontinued the production of it.

The participant in the case 9 and 10 used a generic product in the group G for simple daily writing, and used it by attaching a welfare tool in the group W when a certain level of writing pressure and a long time writing were required.

(2) Each monitor's selection standard for writing tools

The participants in the cases 1 and 2 had no selection standard.

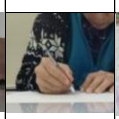
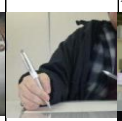
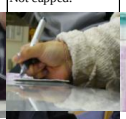
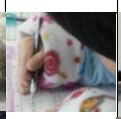
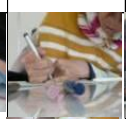
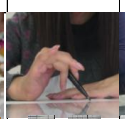
The participants in the cases 3, 4, and 5 pointed out that the lower part of the grip should be thick enough and should not be the cap-type considering their weakening finger strength. The participants in the cases 3 and 5 evaluated the weight ≧15g as too heavy and pointed out lightness as a selection standard. In particular, the participant in the case 5 highly valued the fact that ink ran smoothly even if the point was put at a sharp angle because she usually used the writing tool in a flat angle.

The participant in the case 6 pointed out that the stem of the pen should be slim and the pen should be knock-type as a selection standard because she had to hold it between her extremely small, distorted fingers.

The participant in the case 7 pointed out that the stem should be thick enough to make it easy to grip and the lower grip should be constricted toward the tip to make it not slippery. She pointed out the knock-type pen as a selection standard because she could take out the tip of the pen with a knock on it by her cheek. She did not select the other types because the cap of the cap-type pen was easy to lose and the side button-type pen would easily hold back the tip with just a touch upon it.

The participants in the cases 8, 9, and 10 pointed out the knock-type pen as a selection standard as they could take out the tip of the pen using their chin or a desk, because it could write smoothly even with weak strength and because the cap-type pen was difficult to take out. They also pointed out the fact that the stem was too thin to hold it between their fingers.

(Table 4: Monitors' usual writing tools, selection standards, the way they hold it)

Case	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8	Case 9	Case 10
Disease	Spinocerebellar degeneration	right hemiplegia	Muscular dystrophy	Muscular dystrophy	FOP	RA	Cerebral palsy	Cervical spine injury	Cervical spine injury	Cervical spine injury
Writing tools	Generic ball-point pen	Generic ball-point pen	Generic ball-point pen	Generic ball-point pen	Generic ball-point pen ※Used thick triangular mechanical pencil when she was a student.	Generic ball-point pen	Generic ball-point pen	Generic felt pen Generic 4B mechanical pencil	Mechanical pencil with an omnipotent cuff self-help device. ※Used a felt pen when strength was needed.	Generic ball-point pen ※Used self-help device when strength was needed.
Selection standards	No special standard	No special standard	Not capped. Light Lower grip is thick.	The lower grip is thick.	Ink runs with the sharp angle at the pen tip. The lower grip is thick. Not capped.	Not capped. Slim stem.	Not capped. No button at the side. Not clipped. Stem is thick.	Writes well without applying strength.	The pen tip writes well. Not capped. Knock type. Shoud be thick enough to be attached to an omnipotent cuff.	The pen tip writes well. Not capped. Knock type. The stem is slim.
How to hold										

(3) Usage evaluation of products in the market research group U

Those participants in cases 1 to 5 highly evaluated the writing tools categorized in the upper segment in the group U, which could be used by attaching a grip at a lower part of the body, because they could write smoothly even with weak strength. All other writing tools were evaluated low by them.

The participant in the case 6 evaluated all the writing tools low.

The participants in the case 7 and 10 highly evaluated the writing tools with the V-shaped upper grip categorized in the lower segment in the group U because it wrote smoothly and their fingers could be fixed firmly.

The participant in the case 8 used a tool inflated in the middle that was categorized in the middle segment in the group U for her daily letter writing, but the usage was different from the original product concept.

Although the participants in the cases 9 and 10 used the products in the group G for their daily simple letter writing, they highly evaluated the type of tools that were categorized into the upper segment in the group U which could be used by attaching a lower grip, because the upper end of the tool functioned as a hook for a finger and the lower end functioned as a support for the hand when the stem was held between fingers.

2-2-4. Result of the Motion Analysis

When the efficient writing operation was defined from the viewpoint of functional kinesiology, it was shown to be desirable that comprehensive mutual relation such as the height of a desk, balance of the body trunk, the position of the shoulder joint, the direction of the wrist, the shape of finger and hand joint, the position of eyes could promote a better body position (functional body positions: the shoulder joint won't turn outward, the forearm can touch upon the desk, and the forearm can move effectively within the range from an intermediate position to a pronated position) as well as that the writing tool could be held by the thumb, the 2nd finger, and the 3rd finger.

Based on these viewpoints, we analyzed the writing motions of 10 participants whose hand functions were different from each other. As a result, they were categorized into the following 4 groups. In addition, we found that the position of the lower grip of the writing tool held by the thumb, the 2nd finder, and the 3rd finger as well as the position of the upper grip that came in contact with a hand had a great influence on the writing motions in each group, which was summarized in Table 3.

<A group>: This group had a flexible movement of the forearms, hand joints, and fingers but had weak strength. A total of 3 participants were identified.

● Characteristics of the selected tools and writing motions

Three-point hold by the thumb, the 2nd finder, and the 3rd finger was possible. Deterioration of finger muscle strength and skillfulness were observed, and the strength on the lower grip was weak. Therefore, when writing pressure was necessary, these participants tended to hold the tools between fingers, resulting in the deterioration of the skillfulness of moving the finger tips. Since the fixed power of the 4th finger and the 5th finger were also weakened, which consequently resulted in the weakening of the writing pressure, rubber material with a triangular cross section was used to increase the friction and the contact area with the tools. They preferred the type of tools that they could change the width freely and fix the tool at its position because the upper grip of the tool could shift the hand position and the angle. Also, the knock-type pens were preferred to the cap-type ones, because of the deterioration of strength and skillfulness in hands even though it was possible to hold the tools.

<B group>: This group had a limitation in the movement of the forearms and hand joints, but had flexible movement and weak strength in fingers. A total of 3 participants were identified.

● Characteristics of the selected tools and writing motions

Three-point hold by the thumb, the 2nd finder, and the 3rd finger was barely maintained. However, since there was a limitation in the range of motion of the forearms and hand joints and also there was almost no strength in the fixed power of the 4th and 5th fingers, it was too unstable to hold tools between fingers. They used the writing tools in a flat or at an upright angle because it was impossible to change the direction of the tip of a pen freely. They preferred tools that could maintain the same direction and write well. It was impossible for those participants who used tools in a flat angle to handle the tools inflated toward the lower end because the tip of the pen did not touch the paper. Also, similarly to A group, they tended to hold the tools between fingers when the writing pressure was needed because of a decrease in the muscle strength and finger skillfulness and the lack of control of the lower grip. This consequently resulted in a decrease of skillfulness to move finger tips and led them to apply the rubber material with a triangular cross section for a wider contact area to increase the friction. As compared with A group, the fixed pressure of the 4th and 5th fingers was weak and then the tools became unstable. Therefore the participants tended to prefer the shape of those tools which become stable at the upper grip position that came into contact with a hand. This was particularly true of tools that required a stronger writing pressure. Although it was possible for them to pick up a tool and hold it, they would take out the tip of the pen after holding the tools in their hands firmly because they couldn't switch the grip from one hand to the other sufficiently. They preferred the knock-type pens because the cap-type ones were difficult to handle due to the decrease of muscle strength or skillfulness and because of possibility that their hands might get dirty if they didn't hold the tool firmly when taking out the tip of the pen.

<C group>: This group had a paralysis on the function of the upper limb and fingers and therefore could not sufficiently switch the grip of tools. One participant was identified.

● Characteristics of the selected tools and writing motions

Three-point hold by the thumb, the 2nd finder, and the 3rd finger remained in trouble due to the decrease of skillfulness of fingers and the limitation in range of motion of forearms and fingers. Since they had some level of gripping power, they gripped the tools into the hollow of the palm (power grip) and wrote letters by taking out the tip of the pen to the ulnar side. However, it caused postural distortion because she could not see the tip of the pen. In addition, since writing motion utilized the motions of neither forearm nor hand joints nor fingers but shoulder and elbow, it was impossible to sufficiently write small letters which required skillfulness. Therefore, we modified the shape of the tool so that it could be fixed at both the upper part and the lower part of it to help the participant hold the tool between fingers even without power gripping whenever possible. This enabled her to see the tip of the pen and improve the distortion of her posture. Similarly to B group, the participant in this group tended to move both hands when holding a tool and took out the tip of the pen after gripping it in their hand due to the insufficient re-gripping movement. She preferred the knock-type pens because it was difficult for them to use the cap-type of pens due to the deterioration of skillfulness and because her hands could get dirty if she would not firmly hold the tool before taking out the tip of the pen.

<D group>: This group had severe upper limb and hand dysfunction, could not hold tools firmly, and needed self-help devices. A total of 3 participants were identified.

● Characteristics of the selected tools and writing motions

The participants in this group had severe motor and sensory dysfunction and almost lost hand function. Writing pressure was very weak because they held tools by utilizing the flection or denodesis action of fingers. In addition, they could not move hands at all. When they took writing action, they utilized the motion of shoulder and elbow while fixing the forearm at a pronated position. Therefore, they modified the shape of the tool so that it could be fixed at both the upper part and the lower part of it in order to help themselves hold the tool between fingers because sometimes the hand blocked the sight of the tip of the pen. Usually, when writing pressure is necessary, cuff is often attached to the hand to fix the tool. However, they selected tools similar to those in A group and B group because they could hold tools by utilizing the flection or denodesis action of fingers when they engaged in writing simple letters in their everyday life. They preferred the knock-type pens because it was difficult for them to use the cap-type of pens due to the lack of hand function and because their hands could get dirty if they would not firmly hold the tool before taking out the tip of the pen.

(Table 5: Result of the Motion Analysis of Monitors)

<table>
<tr><td colspan="2" rowspan="2">Clasification of skills</td><td colspan="3">Group A</td><td colspan="3">Group B</td><td>Group C</td><td colspan="4">Group D</td></tr>
<tr><td colspan="3">Group of individuals who could move forearm, hand joints, and fingers but had weak strength.</td><td colspan="3">Group of individuals who had limitations in forearm and hand joints but could move fingers and had very weak strength.</td><td>Group of individuals who had upper limb and hand</td><td colspan="4">Group of indivuduals who had severe limb and hand paralysis and could not hold tools well therefore needed self-help device.</td></tr>
<tr><td colspan="2">Case</td><td>Case 1</td><td>Case 2</td><td>Case 3</td><td>Case 4</td><td>Case 5</td><td>Case 6</td><td>Case 7</td><td>Case 8</td><td>Case 9</td><td>Case 10</td></tr>
<tr><td rowspan="3">Gripping the tools</td><td>Tools selected for easiness of use at the test</td><td colspan="10">  </td></tr>
<tr><td>Tools selected by the individuals</td><td colspan="10">  </td></tr>
<tr><td rowspan="4">Problems of writing motions</td><td>Taking up the tool</td><td></td><td colspan="9">Could not hold a pen by one hand, therefore used both hands. Formed the hand shape first, then held the tool and fixed it.</td></tr>
<tr><td>Holding the tool</td><td colspan="7">Three-point hold was possible, but strength and skillfulness was weakened. Particularly in group B, 4th and 5th finger to hold the tool had almost no strength, which made the tool unstable.</td><td colspan="3">Three-point hold was impossible because of paralysis. Weaving method to hold paper between fingers or grip grasping to hold paper into the palm were used.</td></tr>
<tr><td>Taking out the pen tip</td><td colspan="7">Didn't want to open/close the cap becase of the weak strength. Wanted to use the knock-type to take out the pen tip.</td><td colspan="3">Wanted to hold the tool before taking out the pen tip to avoid the hand to get dirty because re-gripping was impossible. Could not poen/close the cap.</td></tr>
<tr><td>Writing letters</td><td colspan="7">Weak strength and skillfulness led to a decrease in grip force at proximal part of the tool, less control of the tool, and less writing pressure.</td><td colspan="3">Three-point hold was impossible because of finger paralysis. Weaving method to hold paper between fingers or grip grasping to hold paper into the palm were used. Forearm was fixed at the middle or pronated position and skillfulness to move arm and shoulder decreased therefore could not control the size of letters. Grip grasping caused the distortion of posture many times.</td></tr>
<tr><td colspan="5"></td><td colspan="2">Had limitation in motion of forearm and hand joints, therefore could not move the directon of the pen tip freely. Wrote letters in a flat angle, so sometimes the pen tip did not touch paper and the pen tip could not be seen.</td><td colspan="3">The view of the pen tip was blocked by the hand because weaving method to hold paper between fingers or grip grasping method to hold paper into the palm were used and because forearm was fixed at the middle or pronated position to move forearm and shoulder.</td></tr>
</table>

3. Summary of Design Conditions Obtained from the Research Results

All the research results were examined from multiple points of views to discuss the market needs as follows and the conditions of writing tools designed user-friendly for various people are summarized in the chart along with the user needs obtained from the monitor survey (Figure 1).

3-1. Discussion of User Needs

3-1-1. How to store the tip of the pen

- I don’t want to use the cap-type pens because of the difficulty of opening and closing the cap.
- I don’t want to use the side button-type pens because they are glitch-prone.

●I prefer the knock-type pens to protect hands from getting dirty because I want to firmly hold the tool before taking out the tip of the pen. The pen should not cause any pain or slip when I knock it with the desk or my face.

3-1-2. The tip of the pen

●The ink should run easily and the tip should roll smoothly so that it can be handled easily with feeble strength.

●The tip of the pen should touch the paper when holding the tool at a sharp angle and the ink should run easily in this situation.

●The tip of the pen should be easily obtainable and exchangeable.

3-1-3. The lower grip

●Three-point hold by the thumb, the 2nd finder, and the 3rd finger should be achievable and the contact area by these fingers should be wide enough to increase the fixed power and operability when the muscle strength and skillfulness is low.

●The material should be non-slippery so that the writing pressure can be conveyed to the tip of the pen and fingers can be fixed whenever necessary.

3-1-4. The upper grip

●The contact area between the hand and the tool should be wide enough so that the tool can be fixed with feeble strength.

●The stem of the tool should not be too thick because it is the part to adjust the operation angle of the tool.

●The tool should be free of any fixed angle so that it can be re-gripped in the hand and easy to start to write.

●Power grip may cause the distortion of posture and block the view of the tip of the pen. Therefore, the tool should be held by fingers whenever possible at from mid-forearm position to a pronated position.

●Holding the tool by denodesis action of fingers should be adjusted minutely so that the tool can be held between fingers easily and the angle can be adjusted freely.

3-1-5. Others

●The appearance should not give special impression whenever possible considering the user psychology that prioritizes aesthetics and simplicity over functionality.

●It should be easy to get ready for writing even with a dysfunctional hand and should be easy to handle.

●When it is clipped, it should not interfere with the hand movement in any way it is held.

●It should have the right size and weight to prevent it from rolling on a desk and make it easy to carry in a bag.

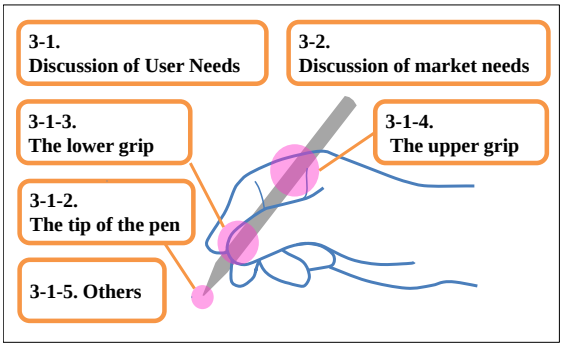
●It should have a weight (≦15g) that is easy to handle even with a weak grip power.

3-2. Discussion of market needs

●When the disabled people are considered as users, it is necessary to clarify the functionality depending on the various physical characteristics and convey the benefits to the buyers as plainly as possible.

●It is necessary to aim for product development that would belong to the group G, which accounts for the majority of the market, reflecting the various people's needs.

●Stable supply of products should be secured in the market.



(Figure 1: Design conditions of writing tools designed user-friendly for various people)

4.Conclusion

In this study, we could grasp various hand functions comprehensively by working collaboratively with occupational therapists who were well trained in the evaluation of physical characteristics of the disabled people, which brought us to the design conditions that would lead to the solution of universal designs.

From the result of the monitor survey that even though the individuals had severe hand function, many of them became skilled in the use of or holding generic tools with a little modification and that there were a variety of ways of holding the tools irrespective of disability, it was suggested that design should not be developed by separating generic products from welfare products since its initial stage.

From the result of the market research and the monitor survey, it was suggested that the product with a concept of easy-to-use for anyone would easily turn out to be had-to-use for the disabled people and low in necessity for the healthy people due to the ambiguous target segmentation. However, these are the needs in the future which need to be addressed continually by applying a new process.

In addition, considering the various profiles of the disabled people obtained from this study, it is impossible to realize the products that will meet the needs of all the people. For those users whose needs were not satisfied by one design, specialists such as occupational therapists would be helpful in identifying the cause of the problems, which subsequently could bring about a new design and lead to a continuous challenge of developing products that are designed user-friendly for as many people as possible.

We believe that the techniques obtained in this study are the ones that cannot be developed by designers alone and that it is a great result of this study that we achieved efficiency and accuracy improvement in a design process. We would like to accumulate these findings as a precious process and know-how of manufacturing designed for various people in the aging society and would like to work on the realization of the products from now on.

6. Examples Citations

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