

以內在實證取向為腦性麻痺個案 選擇合適點選輔具成效之研究

吳亭芳*
臺灣師大復諮所助理教授

張芸婷
彰化縣大同國小特教教師

陳明聰
嘉義大學特教系教授

張千惠
臺灣師大復諮所副教授

電腦是身心障礙者進入主流社會，以及追求學業與職業目標的重要工具。然而，傳統的電腦點選設備，例如鍵盤和滑鼠，無法滿足像腦性麻痺這樣重度肢體障礙個案的需求。因此，為腦性麻痺個案選擇合適的點選輔具一直都是重要的課題，但實務上始終缺乏有系統以客觀資料來協助點選輔具選用的做法。近來實證本位介入成為關注的議題，因此如何收集內在實證以決定合適之點選輔具是值得探討的課題。因此，本文旨在探討結合單一受試設計與評估工具之內在實證資料蒐集過程對腦性麻痺個案選用點選輔具的成效。本研究以三位腦性麻痺患者為對象，利用單一受試交替處理來收集以及比較個案使用不同點選設備的表現。以「肢體障礙者電腦輔具評估量表」以及「電腦化評估」兩種工具來收集資料，並以視覺分析法分析個案使用點選設備的表現。研究結果顯示，利用單一受試交替處理結合前述兩種工具之內在實證過程，三位腦性麻痺患者都獲得了合適的點選輔具。因此，本研究結果支持利用內在實證取向可以協助復健及教育專業人員收集客觀的實證資料，為腦性麻痺個案選擇合適的點選輔具。這樣的過程可作為點選輔具選用實務之參考。

關鍵詞：內在實證取向、單一受試交替處理、腦性麻痺、電腦可及性評估、電腦點選設備

* 本文以吳亭芳為通訊作者 (tfwu@ntnu.edu.tw)。

Introduction

Computers have progressed to become an important tool for accessing new information, maximizing human potential, and redefining power and control in the twenty-first century (Alliance for Technology Access, 2004). For individuals with disabilities, computers are essential for their successful integration into the mainstream community and for their further pursuit of their academic and vocational needs (Mazer, Dumont, & Vincent, 2003). However, standard personal computing systems, such as regular keyboards and mice, cannot meet the needs of individuals with severe disabilities, especially those with physical impairments (Lane & Ziviani, 1997), such as individuals with cerebral palsy.

The condition of cerebral palsy was described as “a persistent disorder of movement and posture appearing early in life and due to a developmental non-progressive disorder of the brain” (Umphred, Lazaro, Roller, & Burton, 2013). The individuals with cerebral palsy usually present difficulties in controlling their movements due to abnormal muscle tone. As a result of their physical limitations, one or more adaptive computer input devices must be provided to meet their special needs. However, how to assist individuals with cerebral palsy in selecting the most appropriate products to meet their personal needs remains a continuing challenge during the rehabilitation process.

Previous studies have proposed assessment protocols for choosing computer input devices for individuals with physical disabilities. Fraser

(1995), for example, developed the physical characteristics assessment to determine appropriate computer access devices for individuals with cerebral palsy. Anson (1994, 1997) developed the Alternative Computer Access Decision Tree as a “road map” to analyze a person’s limitations and identify the most appropriate computer access devices. However, to date, there is no evidence to substantiate the reliability and validity of the above assessment methods. Thus, Wu and colleagues (Wu, Meng, Wang, Wu, & Li, 2002) developed Computer Access Assessment for Persons with Physical Disabilities (CAAPPD) to easily select appropriate alternative computer input devices. This tool evaluates the performance of the client’s actions and permits clinicians to execute the assessment process sequentially via a flow chart. The CAAPPD provides satisfactory inter-rater reliability. The CAAPPD procedure includes the following major steps: (1) assess the needs for seating and positioning adaptation; (2) assess potential anatomical control site allocations; (3) assess keyboard adaptation needs; and (4) assess mouse adaptation needs. Devices for special equipment needs are listed at the end of the assessment.

In addition, other researchers also compared and examined various approaches to help formulate clinicians’ decision making for the computer use of people with disabilities (Angelo, 1992; Lau & O’Leary, 1993). Previous studies suggest that professionals require tools to help them objectively match users with physical disabilities with the correct available computer technology choices (Lane & Ziviani, 2002, 2003). Some assessment tools have been developed, for example, the Test

of Mouse Proficiency was developed by Lane and Ziviani to assess the mouse operation skills of children; the Assessment of Computer Task Performance was for children ages 4 to 13 (Dumont, Vincent, & Mazer, 2002); the Computerized Assessment Tool (CAT) (Chen, Lin, & Ko, 2010) assesses not only the basic pointing performance but also the functional interaction performance as well. However, the aforementioned tools are assessment checklists or software, not comprehensive assessment procedures.

There are many models for delivering assistive technology service, such as the Human Activity Assistive Technology (HAAT) model (Cook & Polgar, 2008) and the Matching Person and Technology (MPT) model (Scherer, 2004), as well as the Student, Environment, Task, and Tool Frame (SETT) (Zabala, 2005), which provides professionals with a good construct for considering the essential components and procedures of assistive technology assessments. The HAAT model was proposed as a framework for understanding the place of assistive technology in the lives of persons with disabilities. This model has four components—the human, the activity, the assistive technology, and the context in which these three integrated factors exist (Cook & Polgar, 2008). The MPT model describes a comprehensive process to assist both consumer and service provider in making choices best suited to the consumer's need. The most appropriate personal devices were selected via sequential assessments (Scherer, 2004). The SETT frame emphasizes on considering the school environment in which the student performing the tasks when providing assistive technology devices (Zabala, 2005). These

models are similar in that they include elements of the person and his or her activities, and environment.

The value of Evidence-Based Practice (EBP) has been established; three types of evidence should be considered when using EBP: external evidence, personal evidence, and internal evidence (Dollaghan, 2007). Although the external evidence from previous scientific studies could initially provide candidate devices, the scientific gathering of internal evidence regarding performance during the selection process and personal needs should be used to provide evidence for making a final decision. Whatever service model or assessment tool is adopted, how to collect scientific data to assist professionals decide which candidate device is proper for the individual client is essential during the service delivery process.

However, no previous study explored a specific process for collecting evidence. Previous studies have demonstrated the training effects of computer access devices on individuals with physical disabilities. Lau and O'Leary (1993) employed a descriptive case study to compare subjects' performance using three computer input devices. Wu and her colleagues used a single-subject, multiple probe design to examine the effectiveness of using computer access devices to increase speed and accuracy for children with cerebral palsy and individuals with spinal cord injuries (Wu, Wang, Chen, & Wu, 2004; Wu, Wang, & Chen, 2005). Man and Wong (2007) reported a repeated-measure, multiple-treatment design (ABCD) to find the computer access solutions for students with quadriplegic athetoid cerebral palsy. However, these studies were time con-

suming when selecting appropriate devices for individuals with physical disabilities. In addition, some of these studies did not provide enough training after device selection.

Therefore, it is necessary to develop a more concrete selection procedure for collect internal evidence. Alternate Treatment Design (ATD) might be a suite procedure possibly. Compared to other designs, an ATD has some advantages. First, it does not require a baseline when the participants cannot use any type of pointing device (Tawney & Gast, 1984). In addition, an ATD can allow for less interruption of the interventions by alternating the pointing device quickly and randomly changing the order of the device (Tawney & Gast, 1984). Finally, an ATD allows for the comparison of performances during the same phase, which could reduce the duration of appropriate device selection (Alberto & Troutman, 2003; Tawney & Gast, 1984).

Consequently, the purpose of this study is to explore the effect of internal evidence collecting

process on selecting proper pointing devices for persons with cerebral palsy. The concrete research question is “Can the data collected by scientific tools in ATD process assist professionals in selecting the proper pointing devices for individuals with cerebral palsy?”

Process of Selecting the Appropriate Pointing Device

In order to provide a concrete procedure for simulating the device selecting process in this study, a computer access assessment (C2A) framework, integrated from the abovementioned models and flowchart (Cook & Polgar, 2008; Scherer, 2004; Zabala, 2005; Wu et al., 2002) was proposed. C2A framework comprises the major steps for selecting proper devices in the abovementioned models and flowchart. There are five stages: needs identification, assessment, candidate device selection, training, and follow-up. The entire process is shown in Figure 1.

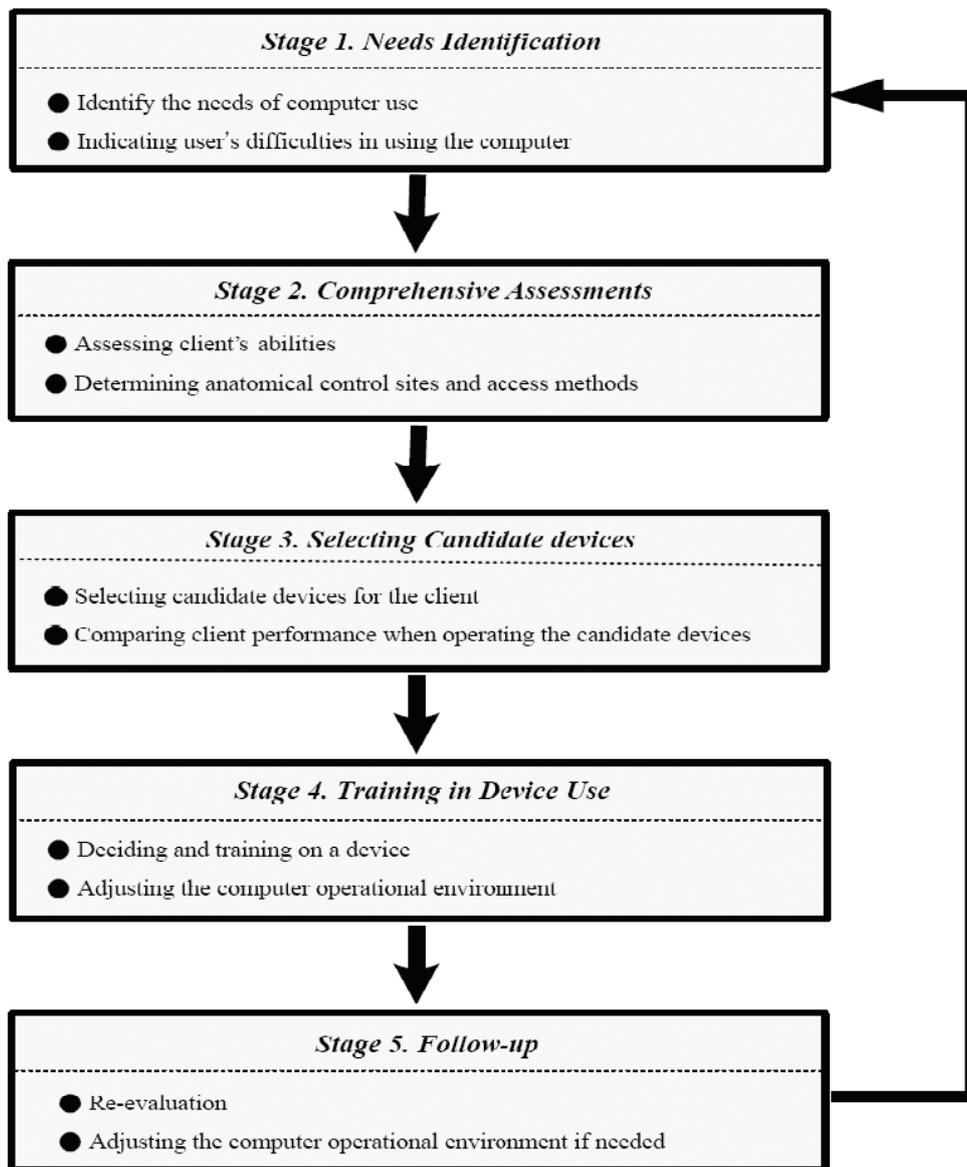


Figure 1 The process of the Computer Access Assessment framework

2.1 Stage 1: Needs Identification

The first stage is ‘needs identification’. In this stage the most critical stage in the process,

service providers collect the information via a written questionnaire completed by, or an interview with, the clients, their family or their care-

givers. This stage includes several tasks, such as identifying the needs for computer use and indicating the user's difficulties in using the computer.

2.1.1 Identifying the needs of computer use

The professional should collect the information including the life and occupational roles of the clients and the activities performed to fulfill those roles (Cook & Polgar, 2008). For example, taking notes in classes and completing assignments at home are major performance areas for a high school student, while playing is an important task for a young child. Therefore, the purpose of the computer use must be identified during this stage as should the client's previous experience in using a computer, previously used input devices, and personal preferences.

2.1.2 Identifying user's difficulties in using the computer

The professional should observe the client's current status in using the computer, and the challenges the client faces in using the computer should be recorded. Individuals with cerebral palsy may encounter difficulties in manipulating a mouse. For example, some may be unable to hold the mouse, while others may not be able to click, double click, or drag the mouse or pointer.

Throughout this stage, the individual's computer use needs are determined. This information provides the basis for the evaluation process.

2.2 Stage 2: Comprehensive Assessments

In the second stage, service providers perform a comprehensive assessment to determine physical control sites and access methods. Some of the mentioned assessment tools, such as the Alternative Computer Access Decision Tree (An-

son, 1994, 1997), the TOMP (Lane & Ziviani, 2002, 2003), ACTP (Dumont et al., 2002) and CAAPPD (Wu et al., 2002), may be used in this stage.

2.2.1 Assessing client's abilities

This evaluation is the most critical component with respect to the client's successful use of computer devices. As the individual's motor, sensory, cognitive, and communicative abilities all play significant roles in the use of the computer, service providers should note the abilities and limitations of their clients in those areas. Knowledge of the client's muscle tone, range of motion, and ability to voluntarily control movement must all be assessed to determine the individual's functional position in using the computer and existing skills to handle devices. Because proper seating or a positioning system can facilitate hand functions (Bergen, Presperin, & Tallman, 1990), it is necessary to assess the needs for adaptive positioning before providing computer access devices.

2.2.2 Determining anatomical control sites and access methods

Physical control sites are determined by evaluating the client's active motion ranges, strength, endurance, and coordination among the client's extremities and his/her head. Fingers and hands are prioritized for use. The head is considered next because the switches can also be placed (1) under the chin, (2) on the forehead, (3) at the side of the cheek or temple, and/or (4) on the back of the head.

2.3 Stage 3: Selecting Candidate Devices

In this framework, the authors propose that two or three candidate devices be selected after the assessment, and the client then be allowed to practice with each of the devices. In addition, an evidence-based method should be used to collect

scientific information to narrow down the selection of the input device. This stage consists of selecting candidate devices for the client and comparing their performances.

2.3.1 Selecting candidate devices for the client

Throughout the comprehensive evaluation, candidate devices are identified for the client (Cook & Polgar, 2008), and usually, two or three input devices are recommended. The most popular devices for people with cerebral palsy include the mouse, trackball, joystick, and multiple switches.

2.3.2 Comparing client performance when operating the candidate devices

After the candidate devices are identified, the client learns how to use these devices and the device performance is recorded. The proper device is selected after comparing the performance, such as the speed and accuracy, as a client performs a variety of tasks such as moving, pointing, clicking and dragging the mouse or pointer.

While collecting internal evidence is critical for making a decision (Dollaghan, 2007), trial and error is not a good method for collecting internal evidence. Instead, a single-subject design is considered a proper method for collecting individual client evidence. Although a withdrawal design has also been used in some studies to explore the effect of different devices (Shin, Chang, & Shin, 2009), Alternative Treatment Design (ATD) is more appropriate for comparing the effect of different treatments (Tawney & Gast, 1984), as ATD allows for the introduction and comparison of two or more devices during the same phase, which could shorten the length of the selection process.

2.4 Stage 4: Training in Device Use

In this stage, the professional decides on the final input device for the client and trains the client on how to effectively use the device. In addition, the client's computer operational environment is adjusted to maximize the client's performance.

2.4.1 Deciding and training on a device

The professional and the client discuss the client's performance in using different input devices and decide which device/s may be the most efficient based on the data (e.g., the outcomes of the speed and the accuracy of pointing and clicking) in the previous stage. After the most efficient device has been selected, the professional trains a client to use the device in therapeutic sessions so the client can attain optimal performance. User preference is also considered during this stage.

2.4.2 Adjusting the computer operational environment

The professional will adjust the sizes of the mouse cursors and icons and tune the speed of the mouse cursors to establish a suitable operational environment for the client. These parameters should be determined during the earlier evaluation stage.

2.5 Stage 5: Follow-up

After one or two months, the professional checks to see if the selected device meets the client's needs. Sometimes, a re-evaluation or minor adjustment may be required.

As the C2A framework indicated, typically the professionals select proper devices for the client after identifying the needs and assessing the capabilities. Internal evidence should be collected during stage 3 and stage 4 to exam whichever is proper for the client.

Method

3.1 Participants

Three individuals with cerebral palsy lived in a residential institute participated in this study. They were referred to the researchers because they demonstrated difficulties in using a standard keyboard and mouse. Informed consent was obtained from each participant or guardian before the assessments.

David is a 35-year-old male with a diagnosis of spastic-type cerebral palsy who never received a formal education. He was not reported with intellectual disability. He had no experience in using computers, but he did show some interest in computer games. His upper extremities have significant spasticity, which impedes the smooth movement of his hands to use a mouse.

Brian is a 6-year-old boy with a diagnosis of spastic cerebral palsy. He was not reported with intellectual disability. He was referred to the authors to identify effective alternative pointer that he could interact with multi-media material by his teacher. Although Brian currently uses his right hand to manipulate a standard mouse to move a cursor, his performance with that device is not proficient.

Candy is a 29-year-old female diagnosed with cerebral palsy and intellectual disability. As she is unable to walk independently, she depends on a power wheelchair for mobility. She demonstrates poor hand control and uses a trackball to move the mouse cursor. She was referred for further assessments because her performance in using a trackball to interact with cognition training software was not as efficient as the teacher had

expected.

3.2 Experimental Design

3.2.1 Research design

In this study, an ATD without a baseline was used to collect the internal evidence for decision making. Three phases were conducted from stage 3.2 (comparing client performance when operating the candidate devices) to stage 4 (training in device use) of the C2A framework: the comparison phase (stage 3.2) compared the performances of two candidate devices; the training phase (stage 4.1) provided further training with the more efficient device; and the adjusting phase (stage 4.2) adapted the computer operating environment for the specific client.

3.2.2 Tasks for the experiment

Because pointing and single-clicking are the most common tasks performed when interacting with computer games and educational software, this study adopted a point-and-click task as the experimental task, which has been used in the previous study (Lin, Chen, Chang, Yeh, & Meng, 2009). The participants were required to move the mouse cursor to the target, and click on it. The target was a blue circle and disappeared only when the participant correctly clicked on it. All the participants adopted the same tasks in the comparison phase.

According to Fitts' law, the size and the distance of the object decide the difficulty of a task, named as Index of Difficulty (ID) whereby impacts the movement time (Fitts, 1954). Smaller target and longer distance creates higher ID which makes task more difficult. Tasks in two IDs were adopted in this experiment. The diameter of the target for clicking was fixed at 51 pixels to ac-

commodate the participant's motor control challenges. The distance of the cursor movement was set at 170 pixels and 510 pixels. The IDs for these two tasks are 2.74(51*170) and 4.32(51*510). Each ID would display in 8 directions (0, 45, 90, 135, 180, 225, 270, and 315 degrees). Therefore, a participant would perform 32 point-and-click tasks during a trial in the comparison phase, only one task was shown on the screen at a time.

3.3 Tools

There are many tools available. However, CAAPPD (Wu et al., 2002) and CAT (Chen et al., 2010) were used because of their convenience.

3.3.1. Computer Access Assessment for Persons with Physical Disabilities

According to the C2A framework, the aim of stage 1 is to identify the client's needs, the aim of stage 2 is to assess the client's abilities, and the first aim of the third stage is to select the candidate devices. In this study, the authors used CAAPPD to fulfill the above aims (Wu et al., 2002).

Content validity of the CAAPPD was established through a panel of experts in this area, and eight faculty from occupational therapy, special education, and computer education fields were involved in reviewing the assessment items (Wu et al., 2002). Additionally, the inter-rater reliability was investigated through case studies of two senior occupational therapists by simultaneously evaluating clients and independently administrating the CAAPPD flowchart. Correlation coefficients between two raters were between 0.76 and 1.00 (Wu et al., 2002).

3.3.2 Computerized Assessment Tool (CAT)

The CAT (Chen et al., 2010) was used to

measure and record the performances of pointing and clicking. The test tasks in the CAT were developed based on the results of the Delphi survey, and the test-retest reliability of speed also indicated the acceptable reliability for the subtests in the CAT. Additionally, the majority of the Spearman's product-moment correlation coefficients were significant ($r = .26 \sim .78$) (Chen, Meng, Hsieh, Chu, & Li, 2004).

The authors use the CAT to compare the performances between devices in stage 3 and record the training effect in stage 4 of the C2A framework. The CAT system allowed researchers to record the coordinates of the cursor every decisecond and record the activation of the left mouse click. The accuracy, speed, ratio of path/ distance (PL/TA), and movement units were selected as the parameters to represent the input devices' operating performance (Lin et al., 2009). Accuracy refers to the percentage of correct responses. Speed is defined as the distance of the task divided by the time spent completing the point and click task. The ratio of the PL/TA is defined as the actual length of the trajectory of the cursor movement divided by the distance of the task. A higher ratio indicates less efficiency in cursor movement. Movement Units (MU) occurred at the point where the cursor accelerates and decelerates. The CAT system automatically records these parameters.

3.4 Experimental Procedure

Before the experiment, a physical or occupational therapist performed the required comprehensive assessments to determine the participants' needs and to recommend control sites and candidate devices for the participants. Following stage 1 (needs identification) and stage 2 (comprehen-

sive assessments) of the C2A framework, each participant was assessed using the CAAPPD. Two candidate devices for further comparison were recommended for each participant based on the results of the needs identification and comprehensive assessment.

In the comparison phase (stage 3, selecting candidate devices using the C2A framework), the participant was first introduced to a device and then allowed to practice with the device and become familiar with it. A formal performance test was then conducted. After a 10-minute break, the participant received an introduction to the alternative device, and the above process was repeated. In the next session, the order of the devices was reversed to counterbalance the sequence effect. As soon as one candidate device performed better than the other, the more efficient device was selected and the subject proceeded to the next phase, the training phase, to explore the long-term effect of the higher-performing device.

In the training phase (stage 4, training of the C2A framework), the same performance measures procedure used in comparison phase (stage 3) were used to gather data. The participant practiced with an operating device to test if he/she could manipulate it more efficiently. The subject was allowed to practice for 10 to 20 minutes during each session before testing. When the participant's performance reached an 85% accuracy rate in the consecutive 2 trials, which meant he/she had reached a stable status, the training phase was concluded.

Finally, during the adjusting phase, the researchers helped the participants use the pointing device in a typical computer operation environment. During this phase, the same CAT tasks with

smaller icons were used. Participants were asked to practice the new tasks with higher IDs and to take a test similar to the tests taken in the training sessions. To ensure the procedures were carried out exactly, the authors used a checklist to confirm that the process matched with the aforementioned procedures.

Since the participants lived in a suburban institute, they received a trial every two to three days. The experiment was conducted in a quiet computer lab individually.

3.5 Data Analysis

Visual analysis was adopted to analyze the performance of each device in the experiment. The major criterion for assessing performance was accuracy. The other parameters, speed, ratio of path/ distance (PL/TA), and movement units, were auxiliary when making the final decision.

Results

4.1 David

By conducting the evaluation of stage 1 (needs identification) and stage 2 (comprehensive assessments) of the C2A framework, the results indicated that David had better control of his hands than he did of his other body parts. Based on the results of the assessments, an arm slat switch and a joystick with a single switch replacing the function of a mouse left-click were employed to serve as the candidate input devices in stage 3 (selecting candidate devices).

The accuracy, speed, ratio of PL/TA, and MU of the two devices in three phases for David are illustrated in Figure 2. A visual analysis of these four parameters is demonstrated in Appen-

dix 1. In comparison phrase, the trend and level stability of the accuracy rate were 100%, except A2 (33%). The average accuracy of joystick was 75% in A1 and A2 while arm slat switch was 88% in B1 and B2. When comparing David's operating accuracy in using joystick and switch, the trend effect was positive (B1/A1) or no change (B2/A2). The change in level was also positive (B1/A1:63-88; B2/A2:50-75). The percentage of overlap was high (B1/A1:100%; B2/A2:100%) which might due to the small number of data points.

The trend and level stability of speed, rate of PL/TL and MU were all 100% for both joystick and multiple switches except A1. The average of speed (A1=6.2, B1=9.2, A2=10.5, B2=19.6), rate of PL/TL (A1=6.7, B1=2.1, A2=2.5, B2=1.5), as well as MU (A1=104, B1=19, A2=133, B2=35) all indicated David performed better in same task when using the arm slat switch. Comparing the performance of joystick and switch, the trend effect in speed was negative (B1/A1) or no change (B2/A2), the trend effect in rate of PL/TL was positive (B1/A1) or no change (B2/A2), and the trend effect in MU was positive (B1/A1) or no change (B2/A2). The change in level was all positive. The percentage of overlap was small in speed (B1/A1:25%; B2/A2:0%) and MU (B1/A1:0%; B2/A2:0%), but high in rate of PL/TL (B1/A1:100%; B2/A2:100%).

The results of visual analysis of accuracy, speed, rate of PL/TL, and movement units (MU) parameters all indicated that David performed better when using the arm slat switch. Therefore, based on the results of these parameters (internal evidence) and David's preference (personal evi-

dence), the arm slat switch was selected for further training.

In the training phase (stage 4 of the C2A framework), the trend and level stability was almost 100% in four parameters. The average accuracy and speed continually increased. Comparing the performance of joystick in comparison phrase, the trend effect was positive or no change in accuracy, rate of PL/TL, and MU. However, the trend effect of speed was negative or no change. Change in level was all positive in these four parameters. Except C1/A1 in accuracy and in rate of PL/TL, all the percentages of overlap were low or zero in four parameters.

Finally, the authors lessened the diameter of the icons from 51 pixels (roughly equal to 1.5 cm) to 34 pixels (roughly equal to 1 cm) on the screen to explore if the regular but smaller icons are suitable for David? However, poor performance resulted when the authors minimized the sizes of the icons in the adjusting phase. In addition, the speed also decreased, though the number of movement units decreased slightly.

Based on the personal evidence, David preferred to use the arm slat switch, and the internal evidence that demonstrated abovementioned, the authors concluded that the most useful pointing device for David was the arm slat switch and that the proper environment was large-size icons.

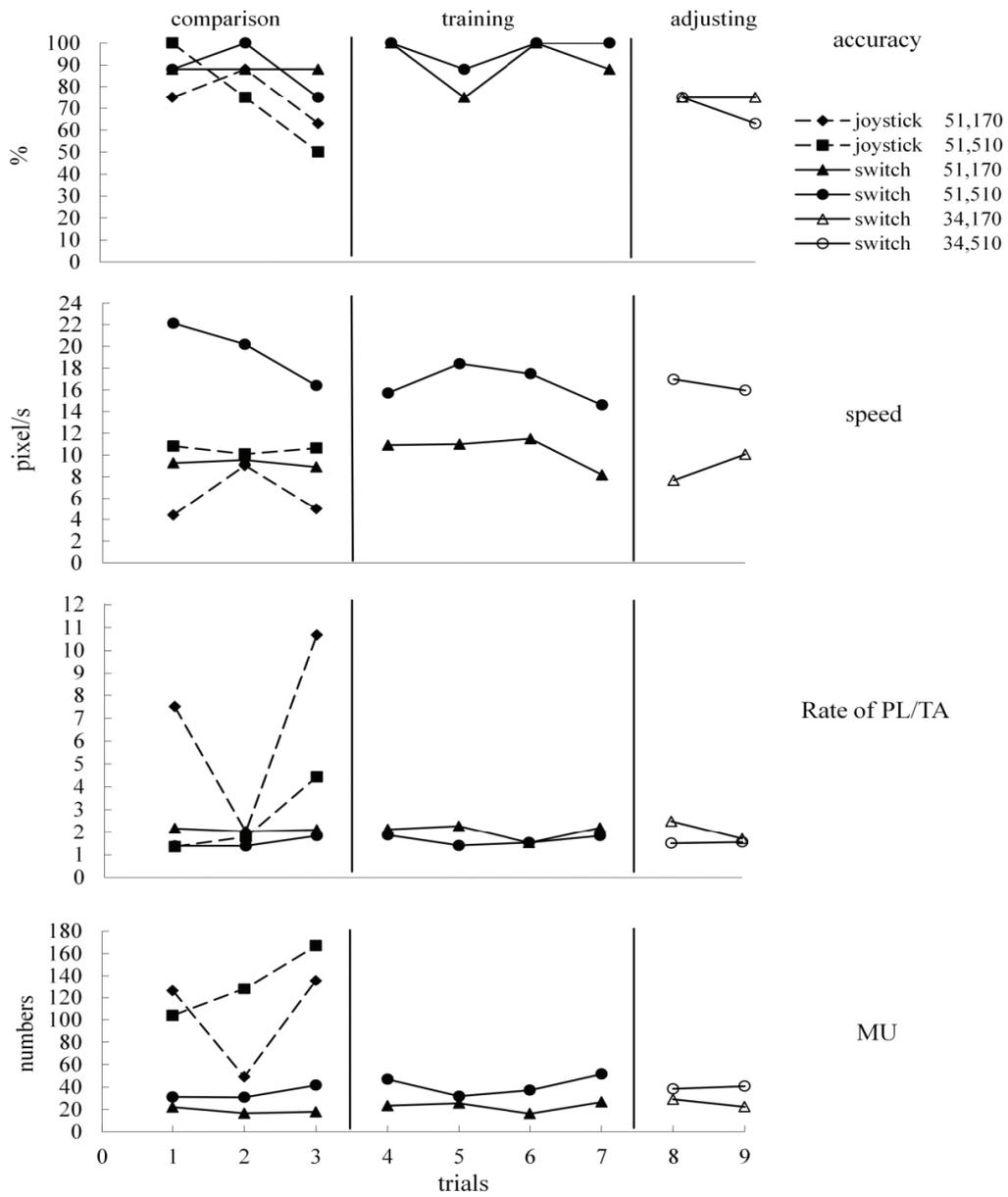


Figure 2 David's performance in the comparison, training and adjusting phases

4.2 Brian

According to the results of the evaluation following stage 1 (needs identification), stage 2 (comprehensive assessments), and stage 3 (selecting candidate devices) of the C2A framework, Brian's right hand was selected as the major control site as he had better control over it than he did his left hand, and a trackball was selected as an alternative candidate device. Therefore, Brian's performance using the standard mouse that he currently used and his performance using of the trackball were compared.

Brian's performance in the point-and-click tasks is illustrated in Figure 3 and the results of visual analysis are demonstrated in Appendix 2. In the comparison phase, the trend and level stability of the accuracy rate were 100%. The average accuracy rates were 88% (B1) and 92 % (B2) when Brian using the trackball, while the rates were 75 % (A1) and 71 % (A2) in using mouse. When comparing Brian's operating accuracy in using mouse and trackball, the trend effect was positive (B1/A1) or no change (B2/A2). The change in level was also positive (B1/A1:75-100; B2/A2:75-88). The percentage of overlap was low (B1/A1:33%; B2/A2:0%).

The trend stability of speed, rate of PL/TL and MU were all 100% except the rate of PL/TL in A1 (67%) and MU in B2(67%). However, the other parameter, level stability were variable in speed (A1:67%, B1:33%, A2:100%, B2:67%), in rate of PL/TL (A1:33%, B1:33%, A2:100%, B2:67%), and in MU (A1:67%, B1:33%, A2:100%, B2:67%).

The average speed shows that Brian performed more quickly when using a mouse (A1=31.8, B1=19.5, A2=84.6, B2=43.3). The average rates of

PL/TL in mouse is lower than trackball (A1=2.8, B1=4.5, A2=1.7, B2=2.2), but the MU were high in mouse (A1=9.4, B1=17.5, A2=12.7, B2=19.7). Comparing the performance of mouse and trackball, the trend effect in speed was no change (B1/A1) or negative (B2/A2), the trend effect in rate of PL/TL was no change (B1/A1) or positive (B2/A2), and the trend effect in MU were no change (B1/A1 and B2/A2). The change in level was negative in speed and rate of PL/TL, but it was positive in MU. The percentage of overlap was small in all speed (B1/A1:0%; B2/A2:0%), rate of PL/TL (B1/A1:33%; B2/A2:33%), and MU (B1/A1:33%; B2/A2:33%).

Although inconsistent results were found among the different parameters, the accurate rate, as essential parameter, revealed the effect of trackball. In addition, Brian also preferred using trackball. The trackball whereby was selected for further training.

In the training phase (stage 4 of the C2A framework), as Figure 3 shows, Brian improved his trackball operation. The results of visual analysis also revealed that the trend and level were all 100% in four parameters. The average accuracy and speed continually increased. Comparing the performance of mouse in comparison phrase, the trend effect was no change in accuracy, and it was no change or positive in rates of PL/TL. The change in level was all positive in accuracy rates and in MU except C1/A1. All the percentages of overlap were low in four parameters except to the speed at C1/A1 and the MU at C2/A2.

Finally, the size of the icons was reduced from 51 pixels (roughly equal to 1.5 cm) to 34 pixels (roughly equal to 1 cm). As Figure 3 indicates, Brian maintained satisfactory accuracy ratios

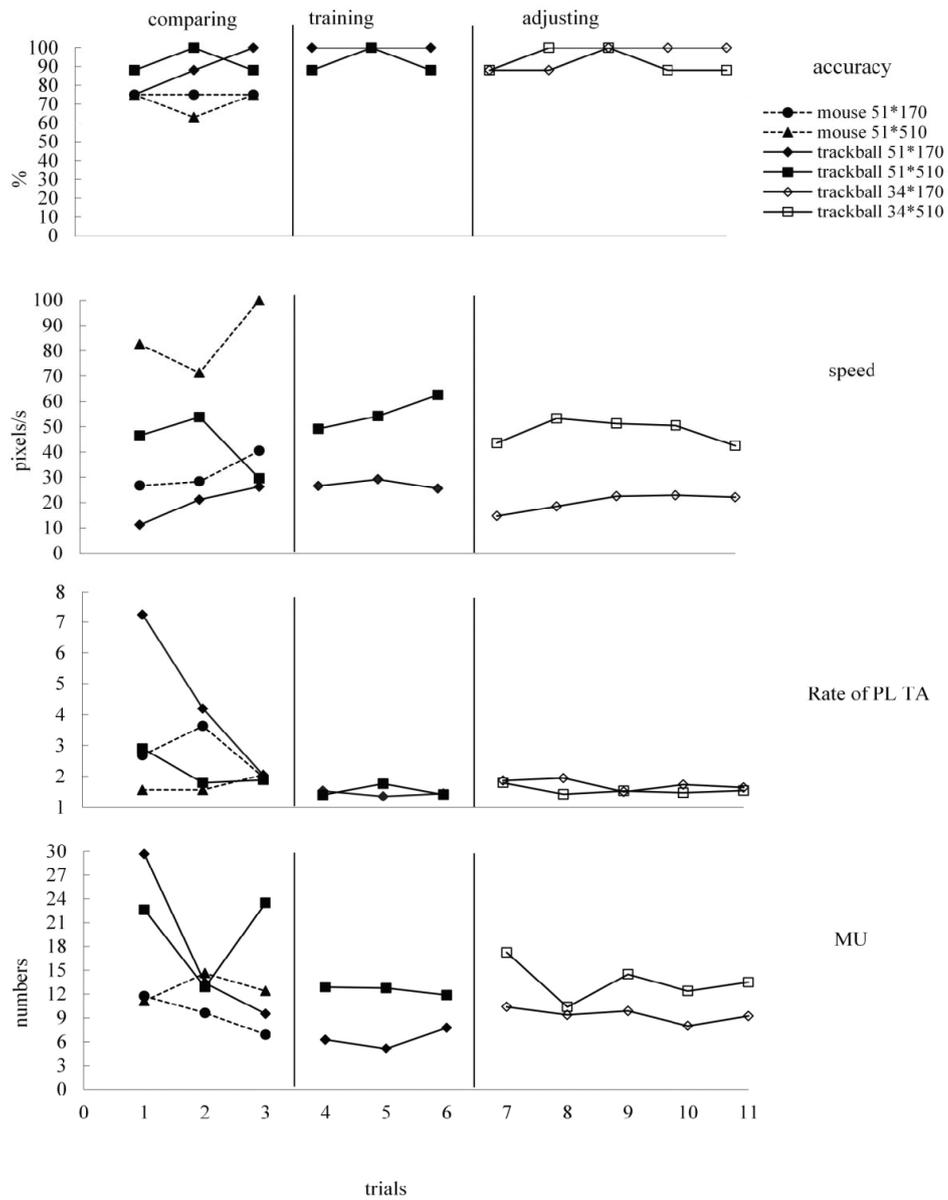


Figure 3 Brian's performance in the comparison, training and adjusting phases

and speeds, though the movement units increased slightly during the adjusting phase.

According to Brian's performance and personal preference, the trackball was selected to replace his mouse, and the icon size was set at approximately 34 pixels.

4.3 Candy

Candy inefficiently used a trackball to move the mouse cursor. By conducting the evaluation in stage 1 (needs identification) and stage 2 (comprehensive assessments) of the C2A framework, a joystick was recommended as an alternative candidate device. The performances of her right hand in operating the trackball were compared to her performance with a joystick.

The results of the parameters are revealed in Figure 4 and a visual analysis is explicated in Appendix 3. In comparison phrase, the trend and level stability of the accuracy rate were not stable. The average accuracy of joystick was 72% in A1 and 69% in A2 while joystick was 91% in B1 and 69% in B2. When comparing Candy's operating accuracy in using joystick and trackball, the trend effect was no change (B1/A1) or positive (B2/A2). The change in level also demonstrated positive (B1/A1:75-88; B2/A2: 75-88). The percentage of overlap was high (B1/A1:100%; B2/A2:100%) which might due to the small number of data points.

The trends and levels for speed were stable only when Candy performing the point-and-click tasks in short distances (A1=100%, A2=50%, B1=100%, B2=50%). The average of speed was higher when Candy used trackball in both short (A1=11.6, B1=13.8) and long distances (A2=19.9, B2=20.7). The trends and levels for ratio of PL/TL were not stable in short distance (tread stability:A1=50%, B1=50%; Level stability:

A1=25%, B1=50%). The MU parameter also illustrated the unstable trends and levels (tread stability:A2=50%, B2=75%; Level stability:A2=50%, B2=25%). However, the average of MU was lower in trackball (A1=18, B1=14, A2=32, B2=31).

Comparing the performance of joystick and trackball, the trend effect in speed was negative (B1/A1) or no change (B2/A2), the trend effect in rate of PL/TL was negative, and the trend effect in MU was no change. The change in level was negative in speed (B1/A1; B2/A2), positive in rate of PL/TL (B1/A1; B2/A2), and negative or no change in MU (B1/A1; B2/A2). The percentage of overlap was high in speed (B1/A1: 50%; B2/A2:75%), in rate of PL/TL (B1/A1:100%; B2/A2:100%), and in MU (B1/A1:50%; B2/A2: 100%).

Although the results of analysis did not reveal the solid effect of trackball, the difference between two devices in accuracy and MU were clear in the last two trails. In addition, the authors discussed the results of the four parameters with Candy and her teacher. Candy's preference was the trackball. Therefore, the original device, the trackball, was recommended for further training, but its position was changed from central to her right hand.

Candy had three training sessions during the training phase (stage 4.1), and she performed more effectively and efficiently using the trackball when it was repositioned. In the training phase, the trends and levels were all stable in all four parameters except 33% in rate of PL/TL in C1. The average of accuracy also improved (C1=92%, C2=96%). Comparing the performance of joystick in comparison phase, the trend effect and change in level for accuracy was positive or no change. Moreover, Candy maintained almost perfect accuracy even when the icon sizes

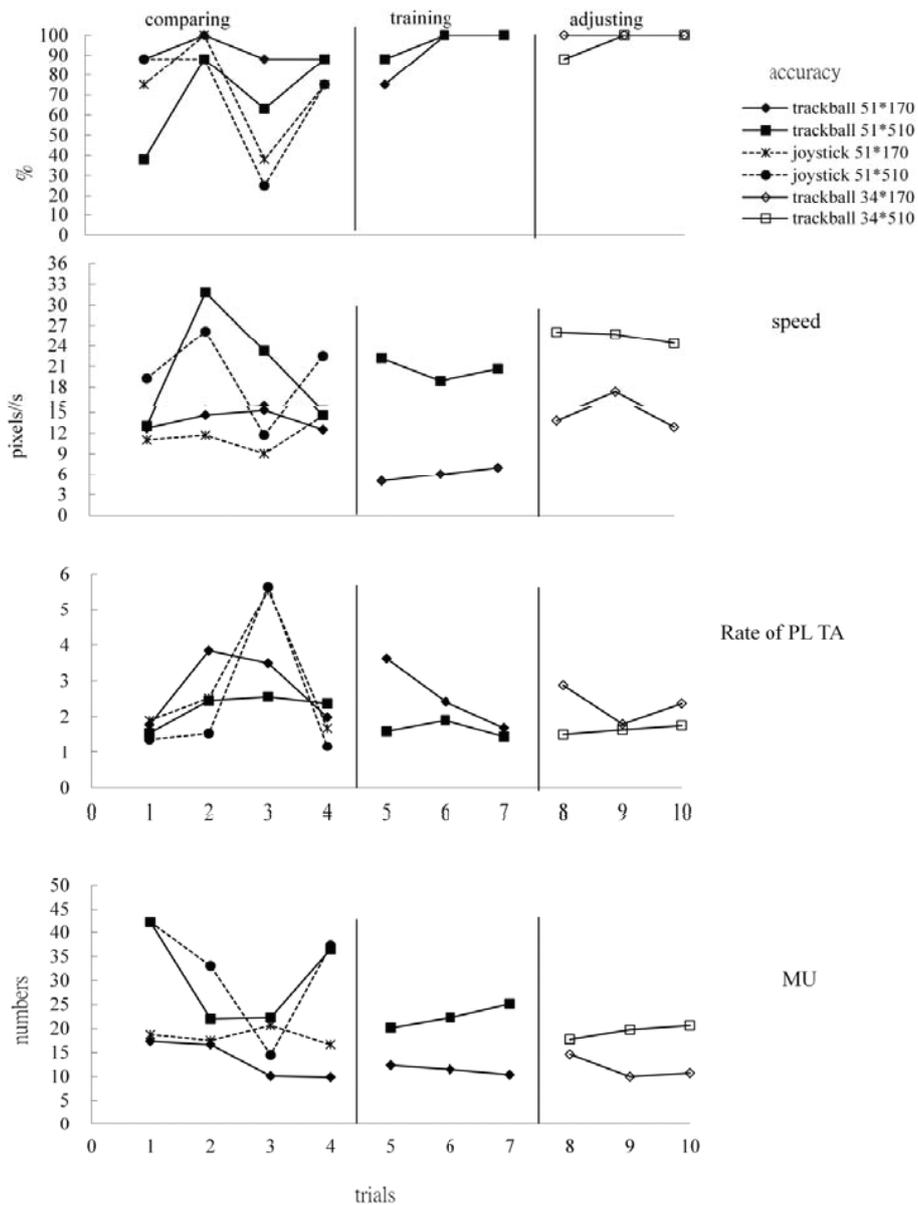


Figure 4 Candy's performance in the comparison, training and adjusting phases

were reduced to 34 pixels. The speed, ratio of PL/TA, and MU were either maintained or improved.

Candy and her teacher were interviewed after the experiment. They accepted that the track-

ball was a suitable pointing device, but that it needed to be positioned properly. After the training and adjusting phases, smaller icon sizes (34 pixels) and her original device, the trackball, were recommended.

Discussion and Conclusion

This study aimed to provide scientific clinical approach, which could collect the internal evidence, to determine an appropriate alternative computer pointer for individuals with cerebral palsy. A single-subject research design was used to illustrate the effectiveness of the process that was administered to 3 clients with cerebral palsy. The results of the experiment demonstrate the effectiveness of internal evidence collecting process in assisting rehabilitation and education professionals to select the most appropriate pointing device for the client based on the scientific information.

As a new pointer user, David's control site was found, and two candidate alternative pointers were selected by following stage 1 and stage 2 of the C2A framework. The control sites of the other two experienced pointer users were also confirmed by the same procedure. Therefore, the control sites could be identified through stage 1 (needs identification) and stage 2 (comprehensive assessments) of the C2A framework. This result serves as evidence for the importance of practice. The experimental process included stage 3.1 to stage 4 in the C2A framework, which collected essential scientific information to assist the clinician in selecting the proper device and icon size. For David, the process led him to a more suitable device by comparing two new alternative devices; Brian was fitted with a new proper device after comparing the trackball with his mouse; and Candy confirmed that her trackball may be the correct pointer for her.

In addition, the training phase (3 to 4 ses-

sions) helped clinical professionals explore the continuing effect of a pointer during training sessions. All three participants demonstrated the benefits of training with the selected device. This process proved to be extremely beneficial as the authors see in the example of David. A device may show initially promising when it is first introduced; however, the effect may decrease after some trials because of the effort required. Meanwhile, the adjusting phase allows the professionals to explore the proper settings by manipulating the size of the icons or the distance of the cursor movements. For example, David could not operate the arm slat switch in a small icon setting, as evidenced by his less accurate performance with smaller icons than with larger ones. However, Brian and Candy could perform well even when the sizes of the icons were reduced. Therefore, the setting for Brian and Candy could be arranged in smaller icons than for David. Two months after the experiment ended, the research team contacted with the staffs of the institute to follow up clients' status of using the selected pointing devices. Based on the replication of the staffs, three clients continued using the pointing devices and were satisfied with those devices. The results also demonstrated the effectiveness of the stage 3 and 4 of the C2A framework.

The results of the experiment also supported that the C2A framework, when used with the CAAPPD and CAT, could collect objective evidence for making proper evidence-based decisions. Furthermore, the results revealed that even useful models need the proper tools to collect the necessary information. Therefore, it was concluded that the C2A framework maybe used with the CAAPPD in the first two stages and with the

CAT in the third and fourth stages in the future.

An Alternative Treatment Design (ATD) without a baseline was important for collecting essential data during stages 3 and 4. In the previous studies, Wu and her colleagues used a single-subject, multiple probe design to examine the effectiveness of using computer access devices to increase speed and accuracy for children with cerebral palsy and individuals with spinal cord injuries (Wu, Wang, Chen, & Wu, 2004; Wu, Wang, & Chen, 2005). Three stages, a baseline phase, an intervention phase, and a follow-up phase were implemented. More than ten sessions were needed to select a device for individuals with cerebral palsy or spinal cord injury. The process was both time and effort consuming, and it is not practical for therapists in clinical setting to spend more than ten sessions selecting a computer device for clients.

The authors of the present study believed that an ATD without a baseline could increase the speed of the selecting process, and the results of the experiment with these three participants support that belief. However, an ATD with a baseline or a withdrawal design should be explored in future studies.

The process of collecting internal evidence proposed in this paper demonstrated effectiveness in selecting proper pointing devices for individuals with CP. Finally, regarding future studies, the use of the candidate device in real-world settings to verify the performance and to determine whether the device could perform better in real situations should also be examined.

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Appendix 1: Visual analysis of accuracy, speed, ratio of PL/ TL, MU of David

Parameters Phrase	Accuracy(%)				Speed(pixel/second)				Rate of PL/TL				MU(number)						
	A1	B1	A2	B2	C1	C2	A1	A2	B1	B2	C1	C2	A1	A2	B1	B2	C1	C2	
Within phrase																			
Condition length	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4
Estimate of trend direction	↘	↘	↘	↘	↘	↘	↘	↘	↘	↘	↘	↘	↘	↘	↘	↘	↘	↘	↘
Trend stability (%)	100	100	100	100	100	100	100	100	100	100	100	100	67	100	67	100	67	100	100
Average	75	88	75	88	91	97	6.2	9.2	6.2	9.2	10.5	19.6	10.4	16.6	6.7	2.1	2.5	1.5	2.0
Level stability (%)	100	100	33	100	67	100	67	100	100	100	100	100	100	100	33	100	33	100	100
Level range	63	88	50	75	75	88	4.4	8.9	4.4	8.9	10.1	16.4	8.2	14.6	2.0	2.0	1.4	1.4	1.5
Level change	75	88	100	100	100	100	9.0	9.6	10.8	22.1	11.5	18.4	10.7	2.2	4.4	1.8	2.3	1.9	1.9
	75	88	100	88	100	100	4.4	9.3	10.8	22.1	10.9	15.7	7.5	2.2	1.4	1.4	2.1	1.9	1.9
	63	88	50	75	88	100	5.0	8.9	10.6	16.4	8.2	14.6	10.7	2.1	4.4	1.8	2.2	1.8	1.8
Between phrase																			
Trend effect	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Change in trend stable	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
Change in level	63	50	63	50	50	50	5.0	5.0	5.0	10.6	5.0	10.6	10.7	4.4	10.7	4.4	10.7	4.4	135
Percentage of overlap	88	75	100	100	100	100	9.3	9.3	22.1	10.9	15.7	15.7	2.1	1.8	2.1	1.8	2.1	1.9	22
	100	100	25	100	25	100	25	25	0	25	0	25	0	100	100	100	25	100	0

Comparison phase: A1: joystick, 51*170; A2: joystick, 51*510; B1: multiple switch, 51*170; B2: multiple switch 51*510

Training phase: C1: multiple switch, 51*170; C2: multiple switch 51*510

Appendix 2: Visual analysis of accuracy, speed, ratio of PL/TL, MU of Brian

Parameters	Accuracy(%)						Speed						Rate of PL/TL						MU					
	A1	B1	A2	B2	C1	C2	A1	B1	A2	B2	C1	C2	A1	B1	A2	B2	C1	C2	A1	B1	A2	B2	C1	C2
Within phrase																								
Condition length	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Estimate of trend direction	—	/	—	—	—	—	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
Trend stability (%)	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Average	75	88	71	92	100	100	92	31.8	19.5	84.6	43.3	27.1	55.3	2.8	4.5	1.7	2.2	1.4	1.5	9.4	17.5	12.7	19.7	6.4
Level stability (%)	100	100	100	100	100	100	100	67	33	100	67	100	100	33	33	100	67	100	100	67	33	100	67	100
Level range	75	75	63	88	100	88	88	26.7	11.2	71.3	29.6	25.5	49.1	2.0	2.0	1.6	1.8	1.4	1.4	6.9	9.5	11.1	12.9	5.1
Level change	75	100	75	100	100	100	100	40.5	26.2	99.8	53.8	29.2	62.5	3.6	7.2	2.1	2.9	1.5	1.8	11.8	29.6	14.6	23.5	7.8
	75	75	75	88	100	88	88	26.7	11.2	82.6	46.4	26.6	49.1	2.7	7.2	1.6	2.9	1.5	1.4	11.8	29.6	11.1	23.6	6.3
	75	100	75	88	100	88	88	40.5	26.2	99.8	29.6	25.5	62.5	2.0	2.0	2.1	1.9	1.4	1.4	6.9	9.5	12.4	23.5	7.8
	75	100	75	88	100	88	88	40.5	26.2	99.8	29.6	25.5	62.5	2.0	2.0	2.1	1.9	1.4	1.4	6.9	9.5	12.4	23.5	7.8
Between phrase																								
Trend effect	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Change in trend stable	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
Change in level	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
	75	75	75	75	75	75	75	40.5	40.5	99.8	26.2	99.8	2.0	2.0	2.1	2.1	2.0	2.1	2.1	6.9	6.9	12.4	12.4	12.4
Percentage of overlap	100	100	88	88	100	88	88	26.2	26.2	29.6	26.2	49.1	2.0	2.0	1.9	1.9	1.5	1.4	1.4	9.5	9.5	23.5	6.3	12.9
	33	33	0	0	0	0	0	0	0	0	67	0	33	33	33	33	0	33	33	33	33	33	33	100

Comparison phase: A1: mouse, 51*170; A2: mouse, 51*510; B1: trackball, 51*170; B2: trackball, 51*510

Training phase: C1: trackball, 51*170; C2: trackball, 51*510

Appendix 3: Visual analysis of accuracy, speed, ratio of PL/TL, MU of Candy

Parameters	Accuracy						Speed						Rate of PL/TL						MU					
	A1	B1	A2	B2	C1	C2	A1	B1	A2	B2	C1	C2	A1	B1	A2	B2	C1	C2	A1	B1	A2	B2	C1	C2
Within phrase																								
Condition length	4	4	4	4	3	3	4	4	4	4	3	3	4	4	4	4	3	3	4	4	4	4	3	3
Estimate of trend direction	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Trend stability (%)	50	100	50	75	100	100	100	100	50	50	100	100	100	50	100	100	100	100	100	100	50	75	100	100
Average	72	91	69	69	92	96	11.6	13.8	19.9	20.7	12.2	20.6	2.9	2.8	2.4	2.2	2.6	1.7	1.8	1.4	3.2	3.1	1.1	2.3
Level stability (%)	50	100	25	25	100	100	100	100	50	50	100	100	25	50	100	75	33	100	50	50	50	25	100	100
Level range	38	88	25	38	75	88	9.1	12.5	11.7	13.0	11.3	18.9	1.7	1.8	1.2	1.6	1.7	1.5	1.7	1.0	1.5	2.2	1.2	2.0
Level change	100	100	88	88	100	100	14.5	15.3	26.1	31.8	13.5	22.2	5.6	3.8	5.6	2.6	3.6	1.9	2.1	1.7	4.2	4.2	1.0	2.5
	75	88	88	38	75	88	11.1	12.7	19.3	13.0	11.8	22.2	1.9	1.8	1.4	1.6	3.6	1.6	1.9	1.7	4.2	4.2	1.2	2.0
	75	88	75	88	100	100	14.5	12.5	22.5	14.6	13.5	20.6	1.7	2.0	1.2	2.4	1.7	1.5	1.7	1.0	3.7	3.7	1.0	2.5
Between phrase																								
Trend effect	=		+	+	+	+																		
Change in trend stable	V	V	to	to	V	V	S	S	V	V	S	S	V	V	S	S	V	V	S	S	to	to	S	S
Change in level	75	75	75	75	75	75	14.5	14.5	22.5	14.5	22.5	1.7	1.7	1.7	1.2	1.2	1.4	2.9	1.7	1.7	3.7	3.7	1.7	3.7
Percentage of overlap	88	88	88	75	88	88	12.5	12.5	14.6	22.2	22.2	2.0	2.0	2.0	2.4	2.4	3.6	1.6	1.0	1.0	3.7	3.7	1.2	2.0
	100	100	100	100	100	67	50	50	75	100	100	100	100	100	100	100	100	100	50	50	100	100	0	100

Comparison phase: A1: joystick, 51*170; A2: joystick, 51*510; B1: trackball, 51*170; B2: trackball, 51*510

Training phase: C1: trackball, 51*170; C2: trackball, 51*510

Selecting an Appropriate Pointing Device or Individuals with Cerebral Palsy by Using an Internal Evidence-based Approach

Ting-Fang Wu

Assistant Professor,

Graduate Institute of Rehabilitation Counseling,
National Taiwan Normal University

Yun-Ting Chang

Teacher,

Tatung Elementary School

Ming-Chung Chen

Professor,

Dep. of Special Education,
National Chiayi University

Chien-Huey Sophie Chang

Associate Professor,

Graduate Institute of Rehabilitation Counseling,
National Taiwan Normal University

ABSTRACT

Purpose: Computers have become a crucial tool for accessing new information, maximizing human potential, and redefining power and control in the twenty-first century. Computers are essential to the successful integration of persons with disabilities into the mainstream community and for these persons to pursue academic and vocational objectives. However, standard personal computing systems, such as regular keyboards and mice, cannot meet the needs of individuals with severe disabilities, particularly individuals with physical impairments such as cerebral palsy. Assisting individuals with cerebral palsy in selecting the most appropriate device to meet their personal needs remains a challenge during rehabilitation. This study explored the effect of an internal evidence collecting procedure, which involved integrating a single subject research design and scientific tools, on selecting appropriate pointing devices for individuals suffering from cerebral palsy. **Methods:** To provide a concrete procedure for simulating the pointing device selection process in this study, a Computer Access Assessment framework was proposed. The Computer Access Assessment framework comprises five major steps for selecting appropriate devices: needs identification, assessment, candidate device selection, training, and follow-up. Three clients with cerebral palsy participated in this study. A single sub-

ject alternative treatment design was adopted to collect and compare the performance of pointing devices for clients with cerebral palsy. Two instruments, the Computer Access Assessment for Persons with Physical Disabilities and Computerized Assessment Tool, were used to collect data. Visual analysis was conducted to analyze the performance of each device in the experiment. The major criterion for assessing performance was accuracy. The other parameters, namely speed, ratio of path to distance, and movement units, were auxiliary when making the final decision. **Findings:** According to the results of the visual analysis, all three clients with cerebral palsy acquired an appropriate pointing device by using the internal evidence-based process. **Conclusions/Implications:** The results of the experiment indicated that the scientific tools, the Computer Access Assessment for Persons with Physical Disabilities and Computerized Assessment Tool, can be employed to collect objective evidence. The process of collecting internal evidence proposed in this study exhibited effectiveness in facilitating the selection of an appropriate pointing device for individuals with cerebral palsy. Finally, future studies are suggested to verify that the device can perform effectively in real situations.

Keywords: internal evidence-based approach, single subject alternative treatment design, individuals with cerebral palsy, computer access assessment, computer pointing devices