Display and device size effects on the usability of mini-notebooks (netbooks)/ultraportables as small form-factor Mobile PCs

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ARTICLE INFO

Article history:
Received 12 April 2013
Accepted 20 January 2014

Keywords:
Input device
Size effect
Mobile PC

ABSTRACTS

A balance between portability and usability made the 10.1” diagonal screens popular in the Mobile PC market (e.g., 10.1” mini-notebooks/netbooks, convertible/hybrid ultraportables); yet no academic research rationalizes this phenomenon. This study investigated the size effects of display and input devices of 4 mini-notebooks (netbooks) ranged in size on their performances in 2 simple and 3 complex applied tasks. It seemed that the closer the display and/or input devices (touchpad/touchscreen/keypad) sizes to those sizes of a generic notebook, the shorter the operation times (there was no certain phenomenon for the error rates). With non-significant differences, the 10.1” and 8.9” mini-notebooks (netbooks) were as fast as the 11.6” one in almost all the tasks, except for the 8.9” one in the typing tasks. The 11.6” mini-notebook (netbook) was most preferred; while the difference in the satisfactions was not significant between the 10.1” and 11.6” ones but between the 7” and 11.6” ones.

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1. Introduction

1.1. Evolution of mini-notebooks (netbooks)/ultraportables as small form-factor Mobile PCs

1.1.1. Multi-device continuity and varied sizes of Mobile PCs

As advances in Internet, wireless communication, and touch-control technologies, Eee PC launched in 2007 and iPad launched in 2010 have triggered mini-notebook (netbooks) and tablet market, respectively. Since then, many computer vendors had been offering netbooks and tablets which are two categories of so-called “Mobile PCs”. Actually netbooks fall into a category of what vendors refer to as “small form-factor” notebooks. Small form-factor notebooks have been known by various names, including subnotebook (ultra-portable, mini-notebook/netbook, ultrabook and mini ultraportable/ultrabook), CloudBook, and ultra-mobile PC (UMPC). There is no clear boundary between each other. Similarly, both powerful tablets (with super portability and enhanced productivity) and tablet-ultraportables (combining the ultraportable features of tablets with the productivity of detachable/dockable/hybrid or sliding/rotating-convertible keyboards, and the flexibility to switch between form factors) blurred the boundary between tablet and laptops. In this scenario, to compete with increased tablet adoption and the shift to touch notebooks and ultra-slim devices with lower-priced solutions, netbooks had been evolved to be “tablet-netbooks/ultraportables” with hybrid or convertible modes of tablets and netbooks; likewise, some small form-factor laptops, so-called “slim-type laptops” (ultraportables, ultrabooks, or mini ultraportables/ultrabooks with less than 14” diagonal screens) have been transformed to be “ultrabooks/ultraportables-tablets”. These phenomena were especially widespread in the second half of 2013 with newly marketed processors aimed to bring more tablet PC-like features (e.g., instance on, all-day battery life, and sleek form factors) to notebook PCs. The tablet-netbooks/ultraportables and “ultrabooks/ultraportables-tablets” eventually converges to be convertible/hybrid “tablet PCs” as one category (except the ones remained as so-called convert/convertible/hybrid or 2-in-1 ultraportables/ultra-slim PCs, e.g. Ultrabook 2 in 1). Thus, it seems that the PC brands have been increasing the number of tablet PC models (including convertibles/hybrids) in their product mixes. According to the data of “Comparison of tablet computers” and “List of Windows 8 and RT tablet devices” (Wikipedia Contributors, 2013a, 2013b) and cross-checking with the brands’ product listings (deducted the overlapping with convertible/detachable Ultrabooks or mini-Ultrabooks) on websites, around 4%, 21%, 13%, 43%, and 19% models in the market were the tablet computers with 5” (and smaller), 7”–7.2”, 7.7”–9.4”, 9.7”–10.8”, 11.6” (and larger) diagonal screens, respectively. The new form factors of convertibles and hybrids contributed 34% (55 in 161) models to the tablet PC market (2009–2013), including merely 9% (1 in 11) the 7.7”–8.3” screen models but around 42% (26 in 62) the 10.1”–10.8” ones (convertible vs hybrid vs slate = 10%:32%:58%), 71% (10 in 14) the 11.6” ones (convertible vs hybrid vs slate = 29%:42%:29%), and 77% (10 in 13)
the 12.1”–12.5” ones (convertible vs hybrid vs slate = 36%:55%:9%), respectively. Among the total desktop market, 62% (46 in 161) table computers were the 10.1”–12.5” screen models of which 52% (46/89) were convertibles/hybrids. Similarly, based on the release of Windows 8 (and latest version Windows 8.1), some ultraportables/mini-ultrabooks have also been evolved to expand the convertible/hybrid form factors of ultrabooks and tablets with 11.6”–15.6” diagonal touchscreens. (Wikipedia Contributors, 2013c) From these market data mentioned above, it was obvious that mini-notebooks/netbooks with 10.1”–12.5” diagonal screens and ultraportables/mini-ultrabooks with 11.6”–15.6” diagonal screens have been evolved with device convergence and responding by adopting the features of both tablets and notebooks that users most appreciated.

1.1.2. Applied tasks, limitation of form factors, and prices of mini-notebooks (netbooks)/ultraportables

With the optimal-sized displays and dedicated keyboards, “tablet-subnotebook/netbooks” and “ultraportable-tablets” allowed sufficient performances to fulfill the needs of a majority of PC users, such as web browsing, e-mailing, social networking, photo sharing, and other Internet-centric activities, as well as word processing and spreadsheet works. According to a recent CEA research study (Consumer Electronics Association, 2013), in U.S. household that 92% and 83% tablet users utilize their tablets to browse the Web and check e-mails, respectively. In addition, tablets are used for more leisurely activities such as playing games (78%), watching videos (66%), and reading e-books (61%). While 46% of them reducing the time spent on laptops, 98% tablet owners have not stopped using laptop. As a result, consumers are gravitating toward connected mobile devices able to perform multiple functions in efficient form factors like laptops or convertible/hybrid tablet PCs with productive keyboards.

To fulfill users’ needs of convenience and efficiency in the growing but fast changing mobile PC market, there is no one-size-fit-all device solution but adoption of appropriate form-factor device to specific task types. In fact, no matter how form factor (including size, shape, and layout) shifts, it simultaneously impacts mobility and productivity. Still, there were two major limitations with small form factors (including subnotebooks, mini-notebooks/netbooks, ultraportables, or their convertible/hybrid tablet modes) — limited viewing area on the screen and inability to type fast without constantly hitting the wrong keys. Consequently, for instance, some 12” tablet-mini-notebooks/netbooks (convertibles) with larger screens and keyboards had been emerged to solve the limitations, while they were almost full-sized laptops which removed certain portability. However, no matter what type of task is applied, the size effect impacts productivity, portability and user’s experience of device usage on any form factors of mobile devices. Thus, for the sake of simplicity, with a range of small form factors in size (from 7” to 11.6” screen diagonal), light weight, and complete with multiple input options (touchscreen, touchpad, and keyboard), netbooks (with touchscreen) were suitable to test and complete with multiple input options (touchscreen, touchpad, and keyboard), netbooks (with touchscreen) were suitable to test and compare on varied application tasks if and how the size effects of displays and or in-put devices impact the usability of ultraportables/mini-notebooks. In terms of focusing on size effects, this study investigated and compared four mini-notebooks (netbooks) with 7”, 8.9”, 10.1”, and 11.6” diagonal touchscreen which might provide valuable information to small form factors of convertible/hybrid tablet PCs/ultraportables, ultra-slim PCs, or similar mobile/portable computing devices.

In addition to the form factors in sizes, given the demands in price-sensitive markets, the average selling prices might also affect the acceptance of products. Generally, most of mini-notebooks (netbooks) were less expensive and lighter than traditional laptop PCs. For example, the standard netbooks’ prices (around US$200–450 in the US market) and typical weights (around 2–3.2 lbs.) were dependent on sizes and features, while many mini-notebooks (netbooks) with expanded features increased costs and weights. On the contrary, the prices of ultra-slim PCs (or ultraportables) have gradually decreased due to maturing panel production process. Recently a generation of low-voltage ultraportables appeared with prices under $600. By the end of 2013, a new generation of Windows tablets (or tablet-ultraportables hybrids) will be launched in a variety of price points, sizes (e.g. around 8” or 10”), and form factors (even under $330 for some 10.1” hybrid devices, e.g. Asus’ tablet-netbook Transformer line, compared to $329 for 7.9” iPad mini). Hence a mini-notebook’s (netbook’s) or ultra-slim PC’s (ultraportable’s) price and weight are dynamic due to features and hardware (and/or software) platforms, and a larger device is not necessarily more expensive or heavier than a smaller one (yet still remain its competitive advantages).

1.2. Literature review

Some researches have sought to optimize display size and object scale for motion-transforming input devices (e.g., for mouse see Tränkle and Deutschmann (1991), Jakobsen and Hornbæk (2011, May; for touchscreen see Oehl et al. (2007)). In the study of mouse experiments, the results indicated that the cursor moved more slowly on a smaller display. The display size effects might be acknowledged as a cognitive effect which surpassed the significant effects of task difficulties. Participants were observed to respond carefree in using the larger display so that the cursor movements were quicker than on the smaller display (Tränkle and Deutschmann, 1991). A recent study (Jakobsen and Hornbæk, 2011; May) of laser mice also reported that the display size effects in the performances of geospatial tasks (using maps of large cities) on a small display were more profound compared to medium and large ones (small: 17.3 × 7.1 cm, 640 × 267 pixels; medium: 52.0 × 213 cm, 1920 × 800 pixels; large: 156.0 × 64.0 cm, 5760 × 2400 pixels; 94 PPI in all conditions). In terms of task completion time and subjective satisfaction, interactive visualization techniques worked well for multi-scale navigation on the medium and large displays but not on small displays (with 7” screens diagonal). However, there was no further study of small to medium sized displays to investigate the optimal size with a balance between portability and performance.

The effects of display sizes were also seen in a study of touchscreen (with stylus) experiments (Oehl et al., 2007). The study showed a strong effect on pointing performances in applied multidirectional serial tapping tasks. A 15” TFT touchscreen (1024 × 768 pixels) was used. The three different display sizes were created by a software program and represented the bright area with the rest area of display kept dark and idle. In this sense, the pixel density (~85.33 PPI) would be the same across the three sizes of displays. The display sizes were 6.00 × 8.00 cm, 12.00 × 16.00 cm, and 18.00 × 24.00 cm with 3.94”, 7.86”, and 11.72” screens diagonals, respectively. The study showed that the tasks were less effective in smaller displays than larger displays. It also suggested to lower task difficulties for smaller display sizes. Nevertheless, up to now, the impact of display effects and its interaction with pixel sizes for the tasks with finger-operated touchscreens were not investigated yet.

Regarding the size effects of input devices, a study ofgraphic tablets steering tasks (Accot and Zhai, 2001) revealed that device (active tablet area) sizes and movements scales influenced input tasks with a U-shape performance-scale function. The small scales (57 × 38 mm and 28 × 19 mm) and large scale (455 × 303 mm) degraded task performances because their performances were limited by motor precision and the arm dexterity, respectively;
whereas medium range scales (227 × 151 mm and 114 × 76 mm) did not significantly influence performances. An early research of keyboards (Yoshitake, 1995) also indicated device size effects that keyboard sizes hindered further reduction for the sizes of small computers. Keys scale reduction would influence keyboard availability, while the small keyboard with 16.7 mm key center-line spacing had no performance degradation compared to a conventional keyboard (with 19 mm key center-line spacing). Although there have been many studies of input devices tasks, the literature did not provide any experimental evidence of the possible interactions between display size effects and the size effects of the touchpad or keyboard. Thus, this study investigated the effects on the performances of these input devices, and illustrated the interactions between the display size effects and the device size effects.

Besides, previous researches (e.g., Sutter et al. (2011); Sutter and Ziele (2004)) specified that target size (i.e., target width W) played an important role more than distance (i.e., amplitude A) did in task difficulty. The differences in movement times for similar IDs (i.e., index of difficulties) but different distance/width combinations were observed in the authors’ touchpad and trackpoint experiments. To calculate movement time based on Fitts’ law (index of difficulty defined by MacKenzie (1992)), target size and distance are used as the decisive variables with the following equation using Shannon formulation of ID (log2 (A/W + 1)): T = a + b log2 (A/W + 1). The pointing technique and/or device being used empirically determined the constants a and b. For a proportional change in cursor movement distance (amplitude) A and target’s width W (results in a different combination of A and W), the ID should remain the same but the scale effects would reflect in different a and b as a different device being used. As a result, the observed movement times were longer with nearer but smaller targets than those with larger but larger targets, and vice versa. However, none of these studies provided direct evidence of this incompatibility to Fitts’ law for the device (touchpad or touchscreen) size effects in common daily (data-processing) tasks or of the interaction(s) between the size effects of the display and devices for mini-notebooks (netbooks)/ultraportables/tablets PCs. Thus, this study examined the direct evidence of this incompatibility by comparing the performances of these input devices with different pixels sizes, and illustrated the interactions between the effects in the results and discussion section.

1.3. The research hypothesis and objectives

According to the above literature review, it was presumed that cursor movements’ perceptual effects would make the sizes of displays and built-in devices significantly and mutually influence cursor movement speed on the displays of (hybrid/convertible) mini-notebooks (netbooks)/ultraportables/tablets PCs. In other words, this study was intended to examine the display and device size effects of mini-notebooks (netbooks)/ultraportables as a reference to the usability of the Mobile PCs with similar small form factors (and their hybrids or convertible modes).

The objectives of the study were divided as follows:

1. To explore the size effects of different built-in devices on operation efficiencies and the impacts of display sizes on other built-in devices of mini-notebooks (netbooks)/ultraportables in common and complex contexts of applied tasks.
2. To understand the optimal touchscreen, touchpad, and keyboard sizes of mini-notebooks (netbooks)/ultraportables.
3. To explore the user preferences on the screen sizes of mini-notebooks (netbooks)/ultraportables for different operations.

2. Materials and methods

2.1. Pre-study

In the questionnaire pre-study described below, the usage of built-in input devices of notebooks was preliminarily investigated. The subjects were 22 college and graduate students (12 male) from Tatung University in Taipei City. The ages of the participants ranged from 20 to 45 years, and their average age was 26.38 years. They were different from thirty volunteer participants mentioned on page 8. All of them had experience with notebook PCs (twelve used notebook PCs on a daily basis, four on a weekly basis, five on a monthly basis, and one on a basis of “other” (other than the above classified frequencies)). The questionnaire included questions regarding what kinds of applications and task patterns the subjects mostly used notebook PCs to engage in and what software they mostly used. Similar with the results of CEA research study mentioned in the introduction, the results of the pre-study survey showed that Internet surfing and words processing were the most common applications mostly using online real-time communication software, Internet browsers and other related software. This result was used as the base to design the operational tasks of the main study.

2.2. Main study

2.2.1. Participants

The unpaid volunteer participants of the study were thirty college and graduate students (15 male) from Tatung University in Taipei City. They did not participate in or learned about the pre-study mentioned on page 7. The ages of the participants ranged from 19 to 43 years (M = 27.23; SD = 5.10). All of them had experience with notebook PCs. Sixteen participants extensively used touchpads and physical keyboards (e.g., laptops, desktop computers) but only had moderate experience using touchscreen devices (e.g., ATM, information kiosks), and fourteen reported extensive experience with touchpads, physical keyboards, and touchscreen devices (e.g., touchscreen phones). Twelve of them used notebook PCs on a daily basis and eighteen of them on a weekly basis. All the participants did not know the purpose of the study.

2.2.2. Apparatus

Generally, the major built-in input devices of mini-notebooks (netbooks) were divided into three types: touchpads, touchscreens, and keyboards. The sizes and types of built-in input devices from different brands slightly varied. Similar to the screen sizes of (hybrid/convertible) tablet devices and ultraportables/mini-ultrabooks, the mini-notebooks (netbooks) were mainly with screen sizes from 7” to 11.6” and with 82%–95% of full-size notebook keyboard. Thus, this study evaluated the representative models: ASUS Eee PC 701SD, 900HA, 1000HG, and 1101HA which were equipped with 7”, 8.9”, 10.1”, and 11.6” screen diagonals, respectively. The screen resolutions of the models were set to 800 × 480, 1024 × 600, 1024 × 600, and 1366 × 768 pixels, with displayed pixel density of 133, 133, 135 PPI (pixels per inch), respectively. The pixel size of all the displays was around 0.19 × 0.19 mm except that the one of 10.1” display was around 0.22 × 0.22 mm, and the refresh rate of all displays was set to 60 Hz (a default value). These four models were equipped with keyboards which were 82%, 82%, 92%, and 95% of regular notebooks’ keyboards (the center-to-center spacing of alphanumeric keys was 15 × 11 mm, 15 × 11 mm, 16.6 × 15.9 mm, and 17 × 16.5 mm), respectively. To fit in the keyboards, their touchpads were nearly proportionally shrunk with the sizes of 45 × 43 mm, 38 mm, 38 mm, and 65 × 50 mm, respectively. A comparable RAS (resistive) touchscreen was installed to each model to compare the touchpad and touchscreen performances on the same model. Each model installed Intel® Atom...
Z520 CPU (512 K Cache, 1.33 GHz, 533 MHz FSB), an ultra-low voltage version of mainstream processors, and 2 GB of RAM. The dimensions of tested touchscreens, pixels, touchpads, and keyboards as well as the weights of the four models are listed in Table 1.

The tasks were performed with the full screens of the 7”, 8.9”, 10.1”, and 11.6” mini-notebook (netbook) displays, respectively. The tasks and measuring interfaces were written in Microsoft Visual Basic. The general interfaces of the software referred the Windows interface. To use the default CD gain value and functions in the Windows XP Operating system across the four models, the cursor movement was not changed in the default “Mouse Properties” panel with “Enhance pointer precision” enabled and affected by acceleration.

2.2.3. Measures

2.2.3.1. Experimental design. In the study, the tests were divided into two parts. The first part comprised two independent variables: the model size (i.e. mini-notebook size) and task type. The model size was divided into four levels depending on the screen size of the models. The task type was divided into five levels depending on the input devices and patterns of tasks. The second part of the experiment was to fill in subjective evaluation questionnaires. Dependent measures comprised operating times, error rates, and the evaluations of discomfort, application, and preference.

2.2.3.2. Task design. According to the results of the pre-study survey, Internet surfing and words processing were the most common applications; in addition, the most commonly used task types were point-and-click/tap for pointing devices and touch typing for typing devices. This result was used as the base to design the operational tasks of this study. Furthermore, Fitts’ style tasks (more focused experiments) were using to further characterize Internet surfing and word processing on displays. This study followed Annex B in the ISO 9241-9 standard “Ergonomic requirements for office work with visual display terminals, Part 9: Requirements for non-keyboard input devices” (ISO, 2002) recommendations to design the purposes, patterns, and steps of Tasks 1–4. Besides, since the design of tasks was geared towards imitating interfaces in the real world, some locations of point-and-click/tap targets were designed to be pre-cued (known) but some were non-pre-cued (not known) to the user before visually identifying it.

Hence, there were five tasks designed in the main study. Tasks 1 (multi-direction clicking) and 2 (multi-direction tapping) were simple tasks. Task 3 (successive selecting and clicking), Task 4 (successive selecting and tapping), and Task 5 (typing) were complex tasks. In Tasks 1 and 2, the selections of the center icon were pre-cued, while the selections of icons surrounding the center icon were not pre-cued. As for tasks 3 and 4, in more random layouts, the selections of icons surrounding the center icon were pre-cued (known) but some were non-pre-cued (not known) to the user before visually identifying it.

In Task 5, touch-typing was pre-cued. As for tasks 3 and 4, the distance (i.e., cursor movement distance, simply called ‘distance’ in the rest of the paper) from “S” (Start) to “F” (Finish) was 200 pixels (i.e., 38.25 mm for the 7”, 8.9”, and 11.6” models; 43.75 mm for the 10.1” model). For Tasks 3 and 4, the total distance from “Button 1” to “Button 5” in sequence was 1000 pixels (i.e., 191.25 mm for the 7”, 8.9”, and 11.6” models; 218.75 mm for the 10.1” model). The IDs for Tasks 1–4 remained the same (2.86 bits (−log2(A/W))¼ 0.19 257) despite both the distance and the target’s width for the 10.1” model tasks were proportionally larger than those for the other tasks.

2.2.3.2.1. Task 1 (multi-direction clicking) and task 2 (multi-direction tapping). In Task 1 (multi-direction clicking), “S” (Start) icon first appeared on the testing screen display. (See Fig. 1) The participant focused the start icon with the touchpad. After the “S” icon had been clicked and disappeared, “F” (Finish) icon subsequently appeared on the display. Participants clicked the “F” (Finish) icon and completed one trial and a new trial was presented.

Likewise, in Task 2 (multi-direction tapping), the participant focused the start icon with the touchscreen. (See Fig. 1) The first step was to tap the “S” (Start) icon (located at the center of the screen), and the second step was to tap the “F” (Finish) icon.

In Tasks 1 and 2, each participant performed the tests 8 times on each model in different directions as one set of tests and finished three sets for each task (i.e., 8 repetitions × 3 sets = 24 trials). According to ISO multi-direction tapping task (ISO (2002); Sena and Moschini (2006)), Tasks 1 and 2 were simplified to locate each “F” (Finish) icon in eight directions (0°, 45°, 90°, 135°, 180°, 225°, 270°, and 315°) relative to the “S” (Start) icon. All the directions of clicking and tapping targets were included in Task 1 and Task 2, respectively. According to the most common applications investigated in the pre-study, users proceeded with pointing and clicking (touchpad)/tapping (touchscreen) at the graphic user interface (GUIs) to interact with selecting targets such as icons, menus, or hyperlinks. To imitate these usage situations, Tasks 1 and 2 (the simple tasks) included both the pre-cued center icon and the non-pre-cued icons surrounding the center icon.

2.2.3.2.2. Task 3 (successive selecting and clicking) and Task 4 (successive selecting and tapping). In Task 3 (successive selecting and clicking), the participant used the touchpad to successively select and click icons. (See Fig. 2) The first step was to click “Button

| Table 1 |
| Dimensions of the screens, pixels, and input devices of four tested mini-notebooks (netbooks). |

<table>
<thead>
<tr>
<th>Original model (ASUS Eee PC)</th>
<th>Touchscreen diagonal</th>
<th>Resolution (pixel)</th>
<th>Pixel density (PPi)</th>
<th>Pixel size (W × D mm)</th>
<th>Screen size (W × D mm)</th>
<th>% of generic keyboard</th>
<th>Center-To-center key size (W × D mm)</th>
<th>Key centerline spacing (mm)</th>
<th>Weight (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>701SD</td>
<td>7 inch</td>
<td>800 × 480 133</td>
<td>0.19 × 0.19</td>
<td>153 × 92</td>
<td>45 × 43</td>
<td>82%</td>
<td>15 × 13</td>
<td>15.5</td>
<td>905</td>
</tr>
<tr>
<td>900HA</td>
<td>8.9 inch</td>
<td>1024 × 600 133</td>
<td>0.10 × 0.19</td>
<td>195 × 113</td>
<td>63 × 38</td>
<td>82%</td>
<td>15 × 13</td>
<td>15.5</td>
<td>1127</td>
</tr>
<tr>
<td>1000HG</td>
<td>10.1 inch</td>
<td>1024 × 600 118</td>
<td>0.22 × 0.22</td>
<td>224 × 130</td>
<td>63 × 38</td>
<td>92%</td>
<td>16.6 × 15.9</td>
<td>17.1</td>
<td>1450</td>
</tr>
<tr>
<td>1101HA</td>
<td>11.6 inch</td>
<td>1366 × 768 133</td>
<td>0.19 × 0.19</td>
<td>257 × 145</td>
<td>65 × 50</td>
<td>95%</td>
<td>17 × 16.5</td>
<td>17.5</td>
<td>1380</td>
</tr>
</tbody>
</table>

Please cite this article in press as: Lai, C.-C., Wu, C.-F., Display and device size effects on the usability of mini-notebooks (netbooks)/ultr-portables as small form-factor Mobile PCs, Applied Ergonomics (2014), http://dx.doi.org/10.1016/j.apergo.2014.01.009
Table 2

Details of task types (patterns), processes and purposes of tasks are indicated as follows.

<table>
<thead>
<tr>
<th>Tasks</th>
<th>Task types</th>
<th>Processes of tasks</th>
<th>Description of designs and purposes for Tasks 1 and 2/Tasks 3 and 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Task 1</td>
<td>Multi-direction clicking</td>
<td>1) Select “S” (Start) icon first appears on the testing screen display. Click the “S” (Start) icon. 2) After the “S” icon has been clicked and disappeared, “F” (Finish) icon subsequently appears on the screen. Click the “F” (Finish) icon. • Conduct the tests 8 times in different directions as one set of tests and finished three sets for this task (i.e., 8 repetitions × 3 sets = 24 trials).</td>
<td>According to ISO 9241-9 multi-direction tapping task, it is simplified to locate each “F” (Finish) icon in eight directions (45°, 90°, 135°, 180°, 225°, 270°, 315°, and 360°) relative to the “S” (Start) icon. • The distance from “S” (Start) to “F” (Finish) is 200 pixels.</td>
</tr>
<tr>
<td>Task 2</td>
<td>Multi-direction tapping</td>
<td>1) Select “S” (Start) icon first appears on the testing screen display. Tap the “S” (Start) icon. 2) After the “S” icon has been tapped and disappeared, “F” (Finish) icon subsequently appears on the screen. Tap the “F” (Finish) icon. • Conduct the tests 8 times in different directions as one set of tests and finished three sets for this task (i.e., 8 repetitions × 3 sets = 24 trials).</td>
<td>According to the pre-study, the most common software applications contained pull-down menus for frequently-used basic control. To imitate this usage situation, Tasks 3 and 4 (the complex tasks) are integrated the two patterns of single tasks ‘selecting’ and ‘pointing’ (‘clicking’ with touchpad in Task 3 and ‘tapping’ with touchscreen in Task 4), and included the selections of the non-pre-cued icons (buttons) at different positions each time.</td>
</tr>
<tr>
<td>Task 3</td>
<td>Successive selecting and clicking</td>
<td>Select and tap</td>
<td>1) Select “Button 1”. The subsequent icon is indicated once the previous one has been selected. 2) Select from “Button 2” to “Button 5” in sequence. • Conduct the tests 5 times as one set of tests and finished three sets for this task (i.e., 5 repetitions × 3 sets = 15 trials).</td>
</tr>
<tr>
<td>Task 4</td>
<td>Successive selecting and tapping</td>
<td>Select and tap</td>
<td>1) Tap “Button 1”. The subsequent icon is indicated once the previous one has been selected. 2) Tap from “Button 2” to “Button 5” in sequence. • Conduct the tests 5 times as one set of tests and finished three sets for this task (i.e., 5 repetitions × 3 sets = 15 trials).</td>
</tr>
<tr>
<td>Task 5</td>
<td>Typing</td>
<td>Type</td>
<td>1) Type the Mandarin texts including Mandarin punctuation marks on the blank space below the window. • Conduct the tests with three paragraphs as one set of tests and finished three sets for this task (i.e., 3 repetitions × 3 sets = 9 trials). • Each paragraph includes more than 50 words (characters) in Mandarin and at least 5 marks, but only the operating times and errors for keying the first 50 words (characters) and 5 marks are recorded.</td>
</tr>
</tbody>
</table>

1”. The subsequent icon was indicated once the previous one had been selected. The successive steps of the tasks were to click from “Button 2” to “Button 5” in sequence.

Likewise, in Task 4 (successive selecting and tapping), the participant used the touchscreen to successively select and tap icons. (See Fig. 2) The first step was to tap “Button 1”, and the following successive steps of the tasks were to tap from “Button 2” to “Button 5” in sequence.

In Tasks 3 and 4, each participant performed the tests 5 times on each model as one set of tests and finished three sets for each task (i.e., 5 repetitions × 3 sets = 15 trials). According to the pre-study, the most common software applications contained pull-down menus for frequently-used basic control. To imitate this usage situation, Tasks 3 and 4 (the complex tasks) were integrated the two patterns of single tasks ‘selecting’ and ‘pointing’ (‘clicking’ with touchpad in Task 3 and ‘tapping’ with touchscreen in Task 4), and included the selections of the non-pre-cued icons (buttons) at different positions each time.

2.2.3.2.3. Task 5 (typing). As for Task 5, its task type was to use a keyboard to touch type. All test materials were presented in the column of a window. Participants touch typed the Mandarin texts including Mandarin punctuation marks on the blank space below the window, and so conducted the tests with three paragraphs as one set of tests and finished three sets for this task. (i.e., 3 repetitions × 3 sets = 9 trials). Each paragraph included more than 50 words (characters) in Mandarin and at least 5 marks, but only the operating times and errors for keying the first 50 words (characters) and 5 marks were recorded.

As the pre-study mentioned, Internet surfing and word processing were the most common applications of notebook PCs. Accordingly, Task 5 was simplified to just type Mandarin words (entered by

![Fig. 1. The testing screen displays for Tasks 1 and 2.](image-url)
Errors were recorded for Tasks 1–4 and defined as the number of mistakes made that were not within target boxes. Errors for Task 5 comprised correctly and uncorrected errors collected from all three paragraphs and then combined for each input device. A corrected error was defined as a sequence of consecutive backspaces occurred. An uncorrected error was defined as any error occurred in the final string.

2.2.3. Procedures. The order of the screen size settings across participants was counterbalanced to minimize the learning effect. The participants conducted tests on different input devices sizes and operating tasks in different orders. The experimental environment was set up as shown in Fig. 4. The chair height and angle were adjusted to suitable positions by the participants. To avoid glare, each participant properly tilted the screen panel of the notebook PC. Referring the previous research and guidelines (Ankrum, 1996; Human Factors Society, 1988; Shieh and Lee, 2007), the distance from the screen to the eyes of each participant was maintained at 60–70 cm. Their viewing angles were set to keep the line of sight and the screen panel at around 90°. All the participants readily recognized the icons and their display on the screens.

Before starting the experiment, the participants were briefed on the process of the study, the built-in input devices, and operational tasks. Participants were requested to proceed with the tasks as fast and correctly as they could, and they had to complete all the tasks. Each participant performed 12 sets of operations per task (4 sizes of models × 3 sets of task operations). To minimize the learning effect, the experiments were conducted in two days, and there was at least a one-day interval between the two days. There were half experiments conducted in each day.

2.2.4. Analysis

2.2.4.1. Data collection. The operation times and processes of the tasks were recorded after the recording software had been started. Errors were recorded for Tasks 1–4 and defined as clicks or taps made that were not within target boxes. Errors for Task 5 comprised corrected and uncorrected errors collected from all three paragraphs and then combined for each input device. A corrected error was defined as a sequence of consecutive backspaces occurred. An uncorrected error was defined as any error occurred in the final string.

After finishing a block of experiments (6 sets of tasks operations in one day), every participant simultaneously filled in a subjective assessment (Likert Nine-point Scale) with five variables: ‘hardware discriminability’ (i.e., visual discriminability for screen), ‘cursor movement’, ‘touchpad performances’, ‘touchscreen performances’, and ‘keyboard performances’. (See Appendix) There were three bipolar response scales for each of the variables: (1) Uncomfortable—Comfortable, (2) Difficult—Easy to apply, (3) Dislike—Like. Each response was rated with 9 as the most favorable response and 1 the least favorable response. Since the ‘price’ and ‘weight’ of a mini-notebook (netbook)/superportable are dynamic due to platform and/or additional features, a larger mini-notebook (netbook) is not necessarily more expensive or heavier than a smaller one, and vice versa. Therefore, these two factors (‘price’ and ‘weight’) were not included in the subjective evaluation of this study.

2.2.4.2. Analysis methodology. There were five repeated measures ANOVA models performed for the five tasks. Each model (a repeated-measures ANOVA for each of the five tasks) compared differences in mean operating time or error rate over the four model sizes. Significant overall F tests were followed by post-hoc pairwise comparison tests with a Bonferroni adjustment for \( a = 0.00833 \) (=0.05/6) to account for the six pairwise comparisons between four model sizes. For subjective measures, the rating data were analyzed with descriptive statistics.

3. Results and discussion

3.1. Analysis on objective performances of tasks

3.1.1. Model size effects

Repeated-measures ANOVAs on the operating times showed significant main effects for the factor ‘model size’ (Task 1: F(3, 87) = 47.452, \( p < .001 \); Task 2: F(3, 87) = 16.502, \( p < .001 \); Task 3: F(3, 87) = 6.260, \( p < .001 \); Task 4: F(3, 87) = 11.495, \( p < .001 \); Task 5: F(3, 87) = 18.597, \( p < .001 \), all \( p's < 0.00833 \). As shown in Table 3, the mean operating times in all tasks for the 11.6” (smallest) model and 7” (largest) model were the lowest and highest, respectively. The effect sizes for the factor ‘model size’ in all the tasks exposed large strength of associations between the model size and the
operating time (partial eta squared value, all $\eta^2 > 0.138$). It revealed that model size explained most dependent variance (operating time). With a mean below 5%, the error percentages were not significantly different between each other. In this study, the participants executed rather correctly and the results were in accordance with those of our lab’s another research regarding similar touchpad tasks (Wu et al., 2008). Some other researches (e.g., for touchscreen see Sears (1991); for keyboard see Wiklund et al. (1987)) have also revealed no significant effect on error rate.

3.1.2. The effects and interactions of display sizes, pixels width, and device sizes

The results of the mean operating times in this study showed that the models with smaller display sizes performed the tasks more slowly, and vice versa. This phenomenon was similar to the results of previous studies (e.g., Oehl et al. (2007)). On the other hand, the results demonstrated that the differences in movement times for the same (or similar) IDs but different distance/width combinations were also consistent with previous studies (e.g., Sutter et al. (2011), Sutter and Ziefe (2004)). The physical dimensions of the target sizes and distances on the 10.1" display were proportionally larger than those of the 8.9" display owing to their slightly different pixel widths (0.22 vs 0.19). Therefore, in the analyses of Tasks 1–4, the operating times were lower for the 10.1" model than for the 8.9" model.

As post-hoc pairwise comparisons showed, however, the differences were not significant (all $p's > 0.00833$) in the operating times for all the tasks between the 8.9" and 10.1" models, the 8.9" and 11.6" models, as well as the 10.1" and 11.6" models, respectively, excluding the performances for the keyboard tasks (Task 5) between the 8.9" and 11.6" models ($p = .001 < 0.00833$). The reason might be that the differences of display sizes (effects of the 8.9", 10.1", or 11.6" models were not largely different from each other (10.1" vs 8.9" = 1.088; 11.6" vs 10.1" = 1.087; 11.6" vs 8.9" = 1.077). Similarly, the differences were not significant between the pixel widths of the 8.9" and 10.1" models (0.19:0.22 = 1.15). In addition, there was no interaction between the effects of display size and pixel size discrepancies of the 10.1" and 8.9" models.

On the contrary, the differences were significant ($p = .001 < 0.00833$) in the operating times for the keyboard tasks between the 8.9" and 11.6" models. It might be because the reduced size (center-to-center spacing of alphanumeric keys) of keyboard of the 8.9" model was significantly different from that of the 11.6" one (17 x 16.5 mm vs 15 x 11 mm = 1:0.59); the device (key) size effect (or the device size effect plus the display size effect) caused the significant differences in the operating times.

Besides, the differences were significant (all $p's < 0.00833$) in the operating times for all the tasks between the 7" model and the other three sized models, excluding the differences between the 7" and 8.9" models for the complex touchpad tasks and for keyboard tasks (i.e., Task 3: successive selecting and clicking, and Task 5: typing; both $p's > 0.00833$), respectively. It might be because of the large discrepancies between the reduced display sizes (induced intense display size effect) of the 7" model and the 10.1" and 11.6" models (10.1" vs 7" = 1.069, 11.6" vs 7" = 1.060), respectively. On the contrary, the reason for the above two exceptional non-significant differences for the complex touchpad tasks and for keyboard tasks between the 7" and 8.9" models might be that the comparatively small discrepancies between the reduced device sizes (induced device size effects for touchpads: 63 x 38 mm vs 45 x 43 mm = 1:0.81; for the key center-line spacing of keyboards: 15 x 11 mm vs 15 x 11 mm = 1:1) affected the input devices performances more than the display size effects did (8.9" vs 7" = 1:0.79). However, compared with the very same discrepancy (1:0.81) between the reduced device (touchpad) sizes of the 7" and 10.1" models, the intense display size effect for the large discrepancy of the reduced display sizes (10.1" vs 7" = 1:0.69) influenced the touchpads’ performances more than the device size effect did.

3.1.3. The effects of the display sizes and the discrepancy of display sizes for non-keyboard tasks

The differences were significant (all $p's < 0.00833$) in the operating times for the simple touchpad tasks (Task 1: multi-direction clicking) and touchscreen tasks (Task 2: multi-direction tapping, Task 4: successive selecting and tapping) between the 7" and 8.9" models’ performances although the discrepancy of the display sizes was not significant (8.9" vs 7" = 1:0.79). On the contrary, the differences were not significant ($p > .00833$) in the operating time for Tasks 1, 2 or 4 between the 11.6" and 8.9" models (11.6" vs 8.9" = 1:0.77) even though the discrepancy of the two display sizes was larger than that of the former one (8.9" vs 7" = 1:0.79). It might be because the 7" (smallest) display induced more effects of display size compared to the 11.6" (largest) display for relatively simple tasks comprised Tasks 1 and 2 (simple tasks) and Task 4 (the touchscreen tasks were relatively simple because of the “intuitive” task type).

3.1.4. The effects and interactions of display sizes, device sizes, and clock speed and/or RAM sizes

Generally, some models of mini-notebooks (netbooks) allowed for overclocking or underclocking of the systems using appropriate utilities (e.g., Eee Super Hybrid Engine utility let users overclock or underclock their Eee PCs). Although functionality, performance, and other benefits of the feature of CPU might vary depending on system configuration, it seemed that the differences in clock speed or RAM size might influence the effects of display and/or input devices on the performances of the models. To see the size effects of display and/or input-devices and avoid the potential confounding effects of the performances by separating from the interactions in between the feature of CPU and RAM, this study unified each of the systems with processor and memory specifications at same clock speed, cache, and FSBS Speed (Intel Atom Z520 CPU: 512K Cache, 1.33 GHz, 533 MHz FSBS), and RAM size (2 GB). In terms of increasing clock speed and RAM size, the size effects might be enhanced or reduced accordingly; however, the incurred influences might be insignificant because the executing and controlling efforts needed even in the complex tasks (such as touchpad and keyboard tasks) might not be significantly different.

3.1.5. The optimal model size(s) balance between portability and usability in specific tasks

Basically, smaller display sizes and device sizes induced portability and also implied more intense effects of display size and device size on performance degradation. For the four sizes of models, the 11.6" and 7" models performed the fastest and the slowest, respectively. The results of this present study confirmed its hypothesis and demonstrated which model size(s) could optimally balance between usability and portability. The sizes of the 10.1" model’s built-in display and input devices were reduced but not largely discrepant from those of the 11.6" model’s (as the comparison for the 11.6" model vs the 10.1" model, 1:0.87 for their displays, 1:0.74 for their touchpads, and 1:0.94 for their keyboards); as a result, the difference was not significant between the performances of the 10.1" and 11.6" models. With mixed effects of display size and device size, even the performances for non-keyboard tasks of the 8.9" model were not significantly degraded.

3.2. Analysis on users’ subjective assessments

After analyzed the results of the subjective assessments (see Table 4), it was found that most of the participants had the highest and lowest preferences on the built-in input devices and individual tasks of the 11.6" and 7" models (with total score 7.74 and 4.01),
respectively. The total scores of the 10.1" and 11.6" models (7.07 vs 7.74) were fairly close to each other while there were big differences between the total scores of the 10.1" and 8.9" models (7.07 vs 5.71).

3.3. The relevance of the findings in industries: appropriate form-factor (in size) to specific task type

Overall, the advantages of a portable/mobile device with a clamshell form factor would be remained with its integrated touchpad and keyboard, which might benefit the performances of documents and spreadsheets editing. From the results of the objective and subjective measures, it was found that the 10.1" model well balanced between the needs of portability and performance with all integrated display and in-put devices. Considering the most preferred choice of the participants and the fastest performance, the 11.6" diagonal screen might best fit in the hybrid or convertible modes of the tablet and mini-notebook (or ultraportable/ultrabook). However, in the view point of manufacturing, the sizes directly impact the costs of the mini-notebook (or ultraportable/ultrabook).

In a recent study comparing touchpad and a mouse on error rates, Among a great deal of researches comparing touchpad and a mouse on error rates, the 10.1" model performed with significant degradation for typing tasks; its constrained keyboard with touchpad might be improved by taking an advantage of a non-conventional touchpad with rearranged positions of buttons (Wu et al., 2013). At least, with adequate performances in all non-keyboard tasks, the 8.9" model was still good in terms of its high portability and relatively lower costs of smaller display and features.

Besides, according to a recent study of laser mice (Jakobsen and Hornbæk, 2011; May) that also reported the display size effects on mice in task completion time (the display size effects on a small display were more profound compared to medium and large ones), it might be likely to attain the results of display size effect similar to that on the touchpads tested in the “multi-direction clicking” and “successive selecting and clicking” tasks of this study. As for the error rates, Among a great deal of researches comparing touchpad and a mouse, some recent studies have indicated high accuracy of mice tasks (e.g., Jakobsen and Hornbæk, 2011; May) and no main effect or interactions between a touchpad and a mouse on error rates (e.g., Hertzum (2013)). Therefore, it seems that the size effects on error rates of mice performances would be also similar to that of touchpad tasks. With the point of view that Mice are still popular for use with portable devices, although the results of this study might imply similar results on Mice, it would be worthy to verify the display size effect on mice in most commonly used (point-and-click) tasks.

4. Conclusions

As the results revealed, it seemed that the closer the touchpad/ touchscreen/keyboard sizes to the regular sizes, the shorter the operation times. Therefore, the differences were not significant in operating times between the 10.1" and the 11.6" models. It was observed that both the effects of display sizes and device sizes on the input devices affected movement times, and the task complexity and/or the constrained device sizes significantly influenced whether the display size effects would be enhanced or reduced by device size effects on motor controls. These above results were consistent with the results of significant scale effects in path steering and typing tasks (e.g., Acott and Zhai (2001); Yoshitake (1995)) and display size effects in simple pointing and multidirectional pointing tasks (e.g., Tränkle and Deutschmann (1991); Oehl et al. (2007)) performances, respectively.

Basically, the subjective assessments confirmed the objective measures. As the results showed, the larger the model size, the higher the score in subjective measure (including ‘visual discriminability for screen’, ‘cursor movement’, ‘touchpad performances’, ‘touchscreen performances’, and ‘keyboard performances’).

### Table 3

Mean operating times (second) and error rates (%) for mini-notebooks (netbooks) (standard deviations in parentheses).

<table>
<thead>
<tr>
<th>Operating times [sec.]</th>
<th>Model size</th>
<th>7&quot; (M1)</th>
<th>8.9&quot; (M2)</th>
<th>10.1&quot; (M3)</th>
<th>11.6&quot; (M4)</th>
<th>p-Value</th>
<th>post hoc</th>
</tr>
</thead>
<tbody>
<tr>
<td>Task 1 (Touchpad)</td>
<td>M1 &gt; M2</td>
<td>1.90 (0.10)</td>
<td>1.71 (0.14)</td>
<td>1.65 (0.14)</td>
<td>1.64 (0.14)</td>
<td>0.000*</td>
<td></td>
</tr>
<tr>
<td>Task 2 (Touchscreen)</td>
<td>M1 &gt; M4</td>
<td>1.79 (0.18)</td>
<td>1.60 (0.17)</td>
<td>1.54 (0.16)</td>
<td>1.52 (0.16)</td>
<td>0.000*</td>
<td></td>
</tr>
<tr>
<td>Task 3 (Touchpad)</td>
<td>M1 &gt; M3</td>
<td>5.44 (0.42)</td>
<td>5.05 (0.56)</td>
<td>4.99 (0.51)</td>
<td>4.94 (0.61)</td>
<td>0.001*</td>
<td></td>
</tr>
<tr>
<td>Task 4 (Touchscreen)</td>
<td>M1 &gt; M4</td>
<td>5.48 (0.40)</td>
<td>5.01 (0.55)</td>
<td>5.00 (0.50)</td>
<td>4.85 (0.38)</td>
<td>0.000*</td>
<td></td>
</tr>
<tr>
<td>Task5 (Keyboard)</td>
<td>M1 &gt; M3</td>
<td>88.03 (7.76)</td>
<td>84.35 (7.76)</td>
<td>79.91 (5.64)</td>
<td>78.59 (5.51)</td>
<td>0.000*</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Error rate [%]</th>
<th>Model size</th>
<th>7&quot; (M1)</th>
<th>8.9&quot; (M2)</th>
<th>10.1&quot; (M3)</th>
<th>11.6&quot; (M4)</th>
<th>p-Value</th>
<th>post hoc</th>
</tr>
</thead>
<tbody>
<tr>
<td>Task 1 (Touchpad)</td>
<td>M1 &gt; M2</td>
<td>4.28 (0.18)</td>
<td>4.26 (0.16)</td>
<td>4.25 (0.07)</td>
<td>4.20 (0.06)</td>
<td>0.111</td>
<td>N/A</td>
</tr>
<tr>
<td>Task 2 (Touchscreen)</td>
<td>M1 &gt; M4</td>
<td>2.23 (0.15)</td>
<td>2.22 (0.19)</td>
<td>2.20 (0.20)</td>
<td>2.19 (0.20)</td>
<td>0.009</td>
<td>N/A</td>
</tr>
<tr>
<td>Task 3 (Touchpad)</td>
<td>M1 &gt; M3</td>
<td>4.76 (0.10)</td>
<td>4.76 (0.10)</td>
<td>4.74 (0.07)</td>
<td>4.74 (0.09)</td>
<td>0.463</td>
<td>N/A</td>
</tr>
<tr>
<td>Task 4 (Touchscreen)</td>
<td>M1 &gt; M4</td>
<td>2.80 (0.23)</td>
<td>2.79 (0.20)</td>
<td>2.78 (0.21)</td>
<td>2.77 (0.22)</td>
<td>0.053</td>
<td>N/A</td>
</tr>
<tr>
<td>Task5 (Keyboard)</td>
<td>M1 &gt; M3</td>
<td>2.81 (0.29)</td>
<td>2.81 (0.15)</td>
<td>2.73 (0.23)</td>
<td>2.69 (0.22)</td>
<td>0.039</td>
<td>N/A</td>
</tr>
</tbody>
</table>

*p < .00833.
Overall, for all input devices tasks, the 10.1” model was as fast as the 11.6 model and the 8.9” model was as fast as the 10.1” model. For the touchpad and touchscreen tasks, the 8.9” model even could be as fast as the 11.6” model. It seems that the 8.9” one might be ideal for performances in touchscreen and touchpad tasks. However, given the similarity of the performance results of the 3 larger screens, the 10.1 size strikes a good balance between size of characters on screen and keyboard, weight of device, battery life, selling price, and user preference. Without significant degradation, all input devices performances of the 10.1” model experimentally rationalized the domination of the 10.1” diagonal screen (33% among the existing tablet computers) in the market (Wikipedia Contributors, 2013a, 2013b) even though buyers drive the mini-notebook (netbook)/ultraportable (as well as hybrid or convertible tablet/ultrabook) market toward larger screen sizes and prefer the 11.6” diagonal screen. Consequently, considering the effects of device size, users could be suggested to select the 10.1” mini-notebooks (tablet-netbooks, ultraportables/mini-ultrabook, or their convertible hybrid tablet modes) with all the optimal input tasks performance and portability, the 11.6” one with the best performance and slightly less portability, or the 8.9” one with superiority in portability and good tasks performance (except for typing).

Acknowledgment

Funding for this project was provided in part by National Science Council (NSC), Taiwan (gs1) (NSC 102-2221-E-036-028-). Special thanks to Ms. Fang-Ling Chen for her helpful suggestions and assistance with the word processing.

Appendix. Subjective Evaluation Questionnaires

Please circle the number that is most appropriate as an answer to the given comments. (Each response is rated with 9 as the most favorable response and 1 the least favorable response.)

1. The ‘visual discriminability’ for the screen of the model during operation was

   Difficult
   1—— 2—— 3—— 4—— 5—— 6—— 7—— 8—— 9

   Uncomfortable
   1—— 2—— 3—— 4—— 5—— 6—— 7—— 8—— 9

   Dislike
   1—— 2—— 3—— 4—— 5—— 6—— 7—— 8—— 9

   Easy to apply

2. The ‘cursor movement’ during operation was

   Difficult
   1—— 2—— 3—— 4—— 5—— 6—— 7—— 8—— 9

   Uncomfortable
   1—— 2—— 3—— 4—— 5—— 6—— 7—— 8—— 9

   Dislike
   1—— 2—— 3—— 4—— 5—— 6—— 7—— 8—— 9

   Comfortable

3. The ‘touchscreen performance’ during operation was

   Difficult
   1—— 2—— 3—— 4—— 5—— 6—— 7—— 8—— 9

   Uncomfortable
   1—— 2—— 3—— 4—— 5—— 6—— 7—— 8—— 9

   Dislike
   1—— 2—— 3—— 4—— 5—— 6—— 7—— 8—— 9

   Easy to apply

4. The ‘touchpad performance’ during operation was

   Difficult
   1—— 2—— 3—— 4—— 5—— 6—— 7—— 8—— 9

   Uncomfortable
   1—— 2—— 3—— 4—— 5—— 6—— 7—— 8—— 9

   Dislike
   1—— 2—— 3—— 4—— 5—— 6—— 7—— 8—— 9

   Comfortable

5. The ‘keyboard performance’ during operation was

   Difficult
   1—— 2—— 3—— 4—— 5—— 6—— 7—— 8—— 9

   Uncomfortable
   1—— 2—— 3—— 4—— 5—— 6—— 7—— 8—— 9

   Dislike
   1—— 2—— 3—— 4—— 5—— 6—— 7—— 8—— 9

   Easy to apply

Please cite this article in press as: Lai, C.-C., Wu, C.-F., Display and device size effects on the usability of mini-notebooks (netbooks)/ultraportables as small form-factor Mobile PCs, Applied Ergonomics (2014), http://dx.doi.org/10.1016/j.apergo.2014.01.009
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