RESULTS

We performed different statistical analyses to investigate the combined influences of age, interfaces and tasks on three major classes of dependent variables: search performance, search process, and change in knowledge structures. The variables are summarized in Table 1.

Variables	Description (IV/DV: independent/dependent variable)
IV: Age	Younger participants (Age from18 to 28); older participants (Age>=60)
IV: Interface	Parts interface; systems interface
IV: Task	Matched task (ex. Doing parts type tasks in the parts interface); mismatched task (ex. Doing parts type tasks in the systems interface)
DV: Search behavior	Number of categories clicked, link decision time, broadness, comprehension time, within-category index
DV: Search performance	Likelihood judgment ratings, accuracy of multiple choice questions
DV: Mental-interface match index	Transformed correlation coefficients between before/after card sorting data and the parts/systems interfaces respectively

Table 1. Summary of variables

Analysis on Background Medical Knowledge

For the medical declarative knowledge, ANOVA test showed that there was an age effect on their accuracy of prevalence rates ($F(1,45)=10.74,\ p<.01$), which implied that older participants had more accurate medical knowledge than younger participants. The result was consistent with the previous study [2].

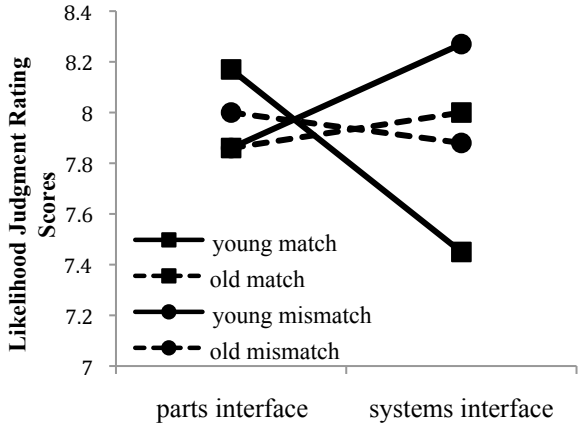

Figure 2. Likelihood judgment rating scores for participants with matching and mismatching tasks and interfaces. The three-way interaction was significant.

Analysis on Search Performance

Effects of Age and Interface on Search Performance

A three-way repeated measures analysis of variance was performed with task, interface, and age as independent variables on their search performance measures, which included the scores of likelihood judgment ratings and accuracy of multiple-choice questions. There were no main effects of age or interface on their scores of likelihood judgment ratings and the accuracy of multiple choice knowledge questions. However, there was a three-way interaction between task, age and interface on the likelihood judgment ratings ($F(1,42)=4.16,\ p<.05$) (See Figure 2).

To understand the three-way interaction, we did two two-way ANOVA by different age groups separately. We found that there was no interaction between task and interface on performance of older adults. The three-way interaction could therefore be attributed to the significant interaction between task and interface on likelihood judgment ratings of younger adults ($F(1,21)=5.08,\ p<.05$). In other words, older adults' judgment performance remained *more consistent* in both matched and mismatched tasks regardless of the interfaces; younger adults' judgment performance, however, *varied* according to the tasks and interfaces. Specifically, when performing a system task in the systems interface, younger participants performed relatively worse, but when performing a parts task in the systems interface, younger adults performed better. This difference was reversed when younger participants were in the parts interface. The results provided support to the intuitive notion that there was an asymmetry between transforming description of body parts to functional body systems and vice versa. This asymmetry of translating different task description to different interfaces in two age groups would be elaborated below.

Analysis on Search Process

Since the judgment performance of younger and older adults interacted with tasks and interfaces differently, we found that their search processes also depended on the interaction between types of tasks and interfaces. During the task, the time people spent on each page and the links clicked were recorded. To better characterize the search process, we created some search behavior variables in our analysis.

Dependent Measures

Broadness measured the total links people clicked in the main category and subcategories pages, which referred to how broad people browsed in one task. *Link decision time* measured the average time people spent deciding on a link click, which reflected the time it took for participants to select a link on a page. *Comprehension time* measured the average time people spent reading the disease descriptions in the final webpage.

Based on previous research, we expected that younger participants would tend to use a more bottom-up interface-driven strategy and older participants would use a more top-down knowledge-driven search strategy. One implication

was that younger participants would more likely follow the interface layout and sequentially click on links grouped under the same category; while older participants would less likely follow the interface layout, but rather rely on the background knowledge to decide which link to click. If this were true, then we would see more within-category consecutive link clicks for younger participants, and more between-category consecutive link clicks for older participants. To verify this claim, we calculated an index that we called the *within-category index*, which was calculated by dividing the number of links clicked on the symptoms page by the number of links clicked on the main category page. A high within-category index implied that participants clicked more links within any main category.

Age Difference on Search Behavior

We performed several repeated measure analyses of variance (ANOVA) with age, interface, and task being independent variables on each of the dependent measures. We consistently observed significant main effects of age on broadness, link decision time and comprehension time *(F(1,42)=16.84; F(1,42)=32.16; F(1,42)=27.11, respectively; all p's <0.001).* We found that older participants clicked on fewer links on the main category and symptoms pages, spent more time deciding on links, and more time comprehending the disease description than younger participants.

Interaction of Age and Interface on Search Process

To better understand how interfaces influenced the search behavior of younger and older participants, we did other three repeated measures ANOVA with age, interface, task (match/mismatch between tasks and interfaces) as the independent variables on the number of categories clicked, within-category index and the link decision time on the main category page. For the number of categories clicked, we found a significant main effect of task (*F(1, 42)=23.26, p<0.001*), with participants clicked on fewer categories when the tasks matched the interfaces than when there was a mismatch (see Figure 3a). In other words, when participants were able to find matching description between the task and the interface, they tended to focus on the matching category (either parts or systems).

The interface x age interaction on the number of categories clicked was significant (*F(1,42)=4.03, p<0.05*). As Figure 3a shows, younger participants clicked on more categories in the parts interface than in the systems interface (*p<0.05*), but for older participants the number of categories clicked in the two interfaces were about the same. This was consistent with the notion that younger participants tended to adopt different strategies in different conditions, but older adults tended to adopt the same strategies.

Because the three-way interaction was not significant, we then did two separate repeated measures ANOVA in the two age groups to understand the effect of interface and task on the number of categories clicked. For younger adults, in addition to the main effect of task, we found there was a significant main effect of interface (*F(1,21)=6.62, p<0.05*). However, for older adults, there was only a main effect of task without any significant effect from the two interfaces. Thus, beyond the tendency that participants clicked more categories if the task mismatched with the interface, younger adults was influenced more by the interface layouts. For the mismatched tasks, younger adults

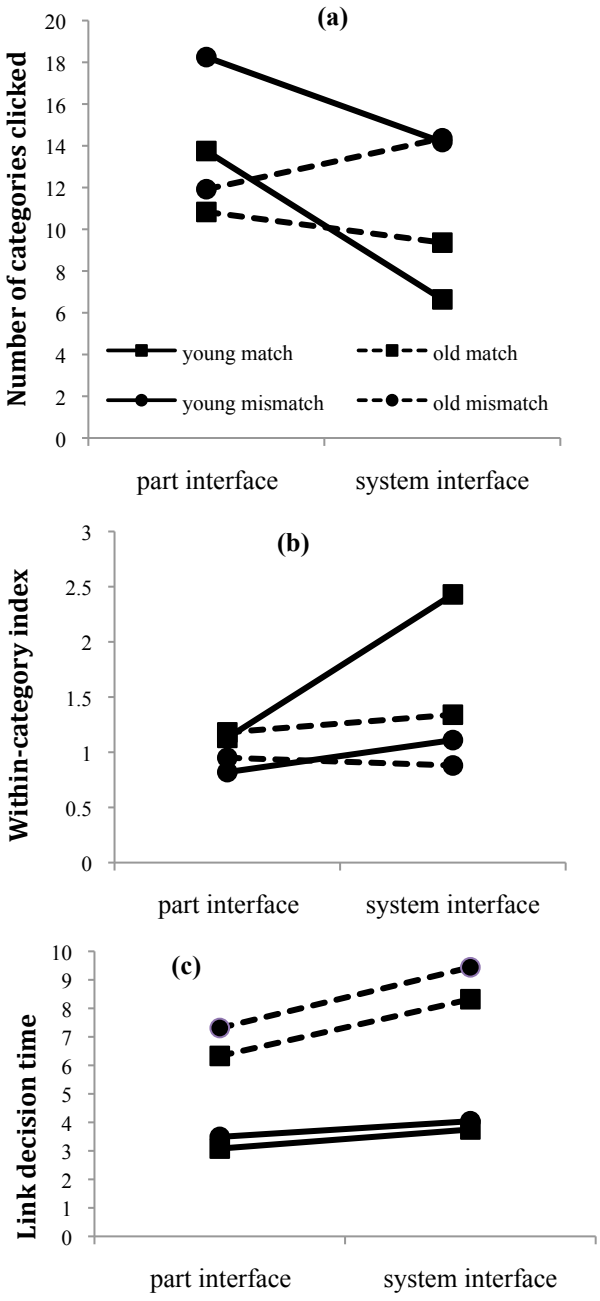

Figure 3. (a) Number of categories clicked, (b) within-category index, and (c) link decision time for younger and older participants when there was a match or mismatch between the task and the interface.

suffered more in the parts interface, suggesting that when given a task with body systems as description in the parts

effect of age was not significant. As Figure 4 shows, the index (correlations between mental categories with those in the interface) was fairly low in the parts interface. Given that the parts interface was designed to be an intuitive interface that allowed participants to associate the body part description with the categories without much medical knowledge, the results were consistent with our expectation that participants' knowledge structures did not change much to conform to the categories imposed by the interface.

In the systems interface, repeated measure ANOVA showed a significant interaction effect between age and before/after ($F(1,18)=5.793$, $p<0.05$) (See Figure 4). We then did the post-hoc test to test the interaction effect. We found the knowledge structures of younger participants became more similar with the systems interface after the task in terms of gaining higher correlations between participants' knowledge structures and interface's semantic structure after the search ($t(10)=-2.14$, $p=0.05$), but the knowledge structures of older adults didn't have significant difference after the search. Thus, we claimed that younger adults, who adopted more interface-driven strategies, would gain more influence from the type of interface, which induced more demands on the users' top-down resources, such as the systems interface in our study. And for this kind of interface, the internal knowledge structure of younger adults would change towards the external knowledge structure of the interface. However, older adults, who adopted more top-down knowledge-driven strategies, were less likely to generate different search patterns across interfaces. Since they tended to adapt to the different tasks only in their head, their knowledge structure remained the same after the search.

To summarize, compared to strategies adopted by older participants, strategies adopted by younger participants were influenced more by the different search environments created by different combination of task description and interface layouts. But we also found that their knowledge structures were influenced more after the interaction with the interfaces than older adults. Results were consistent with the notion that older adults tended to be less influenced by changes in the task environments, and tended to adopt stable, top-down strategies in different situations.

DISCUSSION

Our results showed that younger adults tended to use different strategies but older adults tended to use similar strategies to search when engaged in different combination of tasks and interfaces. Specifically, in the interface that required more top-down resources (i.e., in the systems interface), knowledge structures of younger adults were changed to become closer to the structures of the interface after the search task. However, older adults seemed to have relatively stable search performance, search strategies, and knowledge structures when interacting with two different interfaces across the matched and mismatched tasks.

To answer our research questions, first we did find

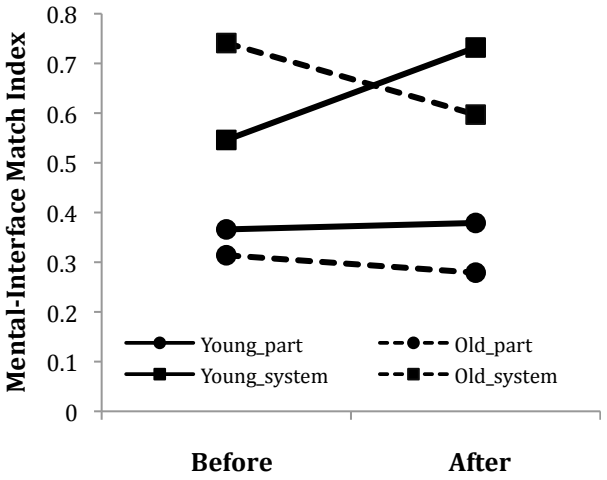

Figure 4. The Mental-Interface Match Index for younger and older participants in the parts and systems interfaces before and after the tasks.

consistent age difference on search strategies. While younger adults used more bottom-up interface-driven search strategies (such as shorter link decision time, higher within-category index and more categories clicked); older adults used more top-down knowledge-driven strategies (such as longer link decision time, lower within-category index and fewer categories clicked). Second, both age groups changed their search patterns according to the matched or mismatched tasks, but with significantly bigger effects in younger adults. The bigger difference in younger adults might have come from the inherent asymmetry of the processes of converting items to different organization (parts to systems was different from systems to parts). Third, the knowledge structures of younger adults were changed in the systems interface, but older adults were found to be more resilient in their knowledge structures.

The natural question was: Given that we did not find any main effect of interface on either search performance or search process of older adults, does this imply they were less adaptive to the different task environments? We would argue that the answer to this question would be a "No". The major reason was that we believe that the stabilized strategy across different interfaces of older adults did not translate to less adaptation. First, according to previous studies [10, 22, 24], the cost of using a different strategy (in this case a more bottom-up search strategy) was higher than its benefit. Because we believe that older participants had better background medical knowledge, the cost of transforming description from parts to systems or vice versa would be lower than those for younger participants. In fact, adopting a bottom-up strategy would have incurred higher costs because of their generally lower perceptual-motor and processing speeds.

From a slightly different perspective, given that the major difference between the interfaces was the different presentation structures of the same information, assuming