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論 文 要 旨

THESIS SUMMARY

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要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words ）

Clinical study of the potential benefits of cognitive training has been ongoing for decades. Despite a number of successful studies that conclusively demonstrated the benefits of certain training regimens, other studies found little or no training gains. The resulting confusion has polarized the academic community and hampered the emergence of consensus guidelines for maximizing any potential training effect.

Recently, cognitive training in the form of game-like smartphone apps has become popular, driven largely by business interests seeking to capitalize on a potentially lucrative new consumer market. While commercial claims of effectiveness are generally drawn from prior clinical studies, the graphical design and overall makeup of consumer apps often differs dramatically from the original clinical tasks upon which they are based.

The goal of this thesis was therefore to look critically at the current state of app-based cognitive training and to specifically examine to what degree screen size, training environment and the game-like visual features that accompany today's popular training products might be impacting training outcomes. To accomplish this, I conducted a series of experiments using both head-mounted and traditional displays in which subjects performed cognitive tasks at different simulated screen sizes and with varying levels of gamification.

In the first experiment, which assessed cognitive activity using EEG, subjects performed an identical task using both virtual reality headsets and LCD monitors. A head-mounted display (HMD) has the effect of suppressing most environmental distractions, while a standard display occupies only the user's frontal visual field, leaving them exposed to both sound and peripheral visual stimuli. My findings showed that subjects demonstrated dramatically increased neural activity when performing the task using an HMD. Since the highest level of activity was recorded in the frontal area in the theta range (4-8Hz), an area shown by prior studies to be closely linked with cognitive effort, these results potentially indicate an increased ability to engage with, and focus on, cognitive tasks when using an HMD. Other potential explanations for the observed effect included a recently documented phenomenon related to distorted depth perception in virtual environments, or the relative novelty of the display technology itself.

The second experiment focused specifically on the potential impact of screen size. Despite the trend towards engaging with cognitive training on small smartphone screens, prior e-learning and perception studies have instead linked improved comprehension and information recall with *larger* screen sizes. To isolate the effect of screen size, subjects in my second experiment performed a simple visual memory task at each of three simulated screen sizes corresponding roughly to smartphone, tablet and television displays. All trials were conducted using an HMD to precisely control stimulus presentation and reduce the chance of external interference. Task performance results showed a clear advantage for the middle size, defined by a 20° visual angle (VA). Trials conducted using the smaller 10° and larger 40° VA resulted in significantly decreased task accuracy and increased reaction times. Likely explanations for the observed effect center around the biology of the human eye, in which the highest optical resolution is found in the macular area of the retina, an area comprising a roughly 18-19° VA. Since the experimental stimuli in the middle size condition (20° VA) fit comfortably within this zone, the superior task performance observed during this condition may have been simply due to a more efficient visual data processing pipeline and a reduction in unnecessary eye movements.

The final experiment involved adding various visual game-like elements to an unmodified task and comparing the results using both performance and EEG outcomes. In contrast to the significant experimental effect observed during the previous experiment, the third experiment revealed no significant performance differences between conditions. This indicates that the addition of these specific types of visual game elements do not appear to interfere with task performance. EEG results echoed this conclusion, with no significant differences in cognitive activity across conditions in the crucial frontal theta rhythm. In contrast, significant differences in EEG power were observed in the beta rhythm and in the theta rhythm in the occipital area for one specific condition. The lack of correlation with task performance, however, suggests that rather than being tied to task demand, this activity may instead reflect greater ocular activity due to the increased visual complexity of the stimulus during those conditions.

In summary, the presentation and size of cognitive training tasks is clearly a factor in achieving optimal performance. There is, however, no evidence in my data to imply that simple game-like elements applied to the task have a negative impact. In fact, since longer-term benefits have been shown to manifest only after a significant investment of time in training, the increased subject motivation and engagement obtained from gamified task design might be instrumental in achieving satisfactory results.