Successful experiences lead to more implicit transfer

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INTRODUCTION
Learning and transfer of behavioral sequences are vital for our everyday life. Our recent work has suggested that people can implicitly transfer learned sequences (Tanaka & Watanabe, 2013); even if participants are not aware of the hidden relationship between learning and transfer sequences, they can transfer their acquired knowledge to a new sequence. In the present study, we examined whether implicit transfer would depend on the number of experience of successful and/or failure trials during learning.

METHODS
218 undergraduate and graduate students participated. All participants had normal or corrected-to-normal visual acuity, normal motor functions, and were naïve to the purpose of this study.

We adopted a basic experimental paradigm used in previous studies (e.g., Hikosaka et al., 1995; Figure 1). The experimental device consisted of 16 LED buttons mounted in a 4 × 4 matrix and another LED button at the bottom (called the “home key”). When the home key was pressed for 500 ms, three out of 16 buttons (i.e., triad) turned on simultaneously, which needs to be uncovered a predetermined correct order of button press by trial-and-error. If button presses were successful, the LEDs turned off, one by one, and a next triad turned on, for which the participants were again required to discover the correct order. If a button press was wrong, all the buttons were briefly illuminated, and the home key turned on (i.e., restart from the first triad). Here, seven triads were presented in a fixed order, which we called a “sequence”. A trial was considered successful when a sequence was completed and an error otherwise. For example, if a participant pressed the wrong button in the second triad, he or she had to start over from the home key. Participants used their index fingers of the dominant hand to press the buttons.

We prepared three types of sequences: “Original”, “Mirrored,” and “Random”. The Original sequence was randomly generated for each participant. In the Mirrored sequence, the spatial configurations of the triads were reversed by the vertical axis from the Original sequence. In the Random sequence, new spatial configurations were randomly generated for the transfer session.

First, all participants were asked to perform the Original sequence in the learning session until they completed successful trials for either 4, 12, 16, or 20 times. After the learning session, they were divided into two groups: Mirrored and Random groups, and asked to perform the assigned sequence for 20 times (transfer session).

After completion of the transfer session, the participants in the Mirrored group were interviewed whether they became aware of the vertically mirrored relationship between learning and transfer sequences. Those who noticed the relationship were regarded as the Aware group and the others were debriefed the relationship and asked again. Those who reported the relationship in this phase, they were also regarded as the Aware group. The remained others were regarded as the Unaware group.

We counted the number of error times, successful trials, and total working time in both learning and transfer sessions.

RESULTS and DISCUSSION
The regression analysis of total working time in the transfer session as a function of the number of successful trials (Figure 2) showed a negative correlation in the Unaware group ($r = -0.09$, $p = 0.58$) and the Random group ($r = 0.068$, $p = 0.50$). These results suggest that the amount of successful trials in the learning session may reduce the working time in the transfer session for the Unaware group.

Figure 1. Examples for sequences used in the present study. Note that displayed numbers on buttons were not shown during sessions.

On the other hand, the regression analysis of total working time in the transfer session as a function of the number of error trials in learning session did not show any negative correlations in all the groups, but rather showed positive correlations (Unaware, $r = 0.25$, $p < 0.05$; Aware, $r = 0.30$, $p = 0.057$; Random, $r = 0.26$, $p < 0.01$; Figure 2). We found also positive correlations between the number of error trials in the learning and transfer sessions in the Unaware group ($r = 0.38$, $p < 0.01$) and the Random group ($r = 0.37$, $p < 0.001$), but not in the Aware group ($r = 0.18$, $p = 0.26$). Thus, these positive correlations may reflect individual differences in error proneness. More importantly, these results suggest that the number of error trials in the learning session do not likely lead to better performance in the transfer session.

The results of the present study imply that the number of completed trials (i.e., successful experience) rather than error trials (i.e., failure trials) in the learning session lead to better implicit transfer.

Figure 2. Total working time in the transfer session as functions of successful trials (left panel) and error trials (right panel).