



Learning a keying sequence you never executed: Evidence for independent associative and motor chunk learning[☆]



Willem B. Verwey^{a,b,c,*}, David L. Wright^c

^a Department of Cognitive Psychology and Ergonomics, Faculty of Behavioral Sciences, Universiteit Twente, PO Box 217, 7500 AE Enschede, The Netherlands

^b MIRA research institute, Universiteit Twente, PO Box 217, 7500 AE Enschede, The Netherlands

^c Human Performance Laboratories, Department of Health and Kinesiology, Texas A&M University, College Station, TX, USA

ARTICLE INFO

Article history:

Received 21 March 2014

Received in revised form 6 May 2014

Accepted 26 May 2014

Available online xxxx

PsycINFO classification:

2330 motor processes

2340 cognitive processes

Keywords:

Keying sequences

Discrete sequence production task

Serial RT task

Processing modes

Associative sequence learning

ABSTRACT

A substantial amount of research has addressed how people learn and control movement sequences. Recent results suggested that practice with discrete key pressing sequences results in two types of sequence learning: associative learning and motor chunk development (Verwey & Abrahamse, 2012). In the present study, we addressed whether in keying sequences of limited length associative learning develops also when the use of the chunking mode is prevented by introducing during practice random deviants. In line with the notion of two different learning mechanisms, the present results indicate that associative sequence learning develops when motor chunks cannot be developed during practice. This confirms the notion that motor chunks do not rely on these associations. In addition, experience with a particular execution mode during the practice phase seems to benefit subsequent use of that mode with unfamiliar and random sequences. Also, participants with substantial video-gaming experience were faster in executing discrete keying sequences in the chunking mode. These last two results may point to the development of a general ability to produce movement sequences in the chunking mode.

© 2014 Elsevier B.V. All rights reserved.

1. Introduction

While in many tasks guidance of sequential motor skills is internal in that movement-specific stimuli are not required (e.g., Goldberg, 1985; Hikosaka et al., 1999), in some other tasks movement sequences are still controlled externally in that individual responses are guided by movement-specific stimuli (e.g., Cohen & Poldrack, 2008). Support for this distinction between internal and external control has been found also in serial key pressing tasks (Verwey & Abrahamse, 2012). Initially, these keying sequences are carried out by reacting to movement-key specific stimuli in the so-called reaction mode. In the case of a fixed keying sequence of limited length (e.g., in the discrete sequence production, or DSP task, Verwey, 2001) practice is assumed to yield integrated memory representations for that sequence that have been called motor chunks. According to the Dual Processor Model these motor chunks are selected as a unit by a cognitive processor, and then executed by

an independent motor processor (Verwey, 2001; for reviews, see Abrahamse, Ruitenberg, De Kleine, & Verwey, 2013; Rhodes, Bullock, Verwey, Averbek, & Page, 2004). Keying sequences executed in this way are said to be executed in the chunking mode. The chunking mode is characterized by the fact that participants make little or no use of the movement-specific stimuli—except for the first one to determine the proper motor chunks.

Indications for a second sequence learning mechanism come from studies using the serial reaction time (serial RT) task (Keele, Ivry, Mayr, Hazeltine, & Heuer, 2003; Nissen & Bullemer, 1987). This task also involves reacting to movement-specific stimuli in the reaction mode. Here participants cycle repeatedly and without interruption through a single sequence consisting of, typically, 12 successive key presses. Despite practice, participants continue to respond to each movement-specific stimulus, and they often do not even notice that there is a sequence at all. Still, responses in the practiced sequence get faster than in a random sequence which is solely based on continued selection of each key. The responsible learning mechanism is assumed to involve the development of associations between representations involved in sequentially reacting to movement-specific stimuli. When these associations develop, the reaction mode gradually changes into the associative mode (Verwey & Abrahamse, 2012). These associations develop at perceptual, central, and motor levels of processing, and they allow priming of the representations used for the ensuing

[☆] We would like to thank Diana Becker, Luisa Breddemann, Gina Ehling, Corinna Gerst, Lotte van der Lelij, Isabel Moning, and Sebastian Schiller for running the experiment.

* Corresponding author at: University of Twente, Department of Cognitive Psychology and Ergonomics, Faculty of Behavioral Sciences, PO Box 217, 7500 AE Enschede, The Netherlands. Tel.: +31 53 489 3611/4764; fax: +31 53 489 4241.

E-mail addresses: w.b.verwey@utwente.nl (W.B. Verwey), d-wright@hlkn.tamu.edu (D.L. Wright).

responses (for a review, see Abrahamse, Jiménez, Verwey, & Clegg, 2010). This associative mechanism allows sequence learning even in probabilistic sequences in which some of the stimuli deviate from a fixed order so that no element can be predicted with certainty (e.g., Jiménez & Méndez, 1999; Schvaneveldt & Gomez, 1998). Apparently, associative learning of a base sequence is not prevented by occasional deviations. It has been argued that associative sequence learning is based on associations between pairs and probably also triplets of stimuli and movement representations (i.e., statistical learning, Perruchet & Pacton, 2006), rather than that a particular movement sequence is being learned.

While skilled execution of DSP sequences has always been assumed to rely on the use of motor chunks, Verwey and Abrahamse (2012) proposed that practice in this task induces associations between successively used representations, too, just like in the serial RT task. This idea was initially based on findings that many older participants improved their execution of discrete keying sequences while they did not exhibit indications for using motor chunks (Verwey, 2010; Verwey, Abrahamse, Ruitenberg, Jiménez, & De Kleine, 2011). Also, when color coding in a serial RT task seemed to induce the use of motor chunks, subsequent removal of color coding made the indications for motor chunk use disappear, but effects of practice remained (Jiménez, Méndez, Pasquali, Abrahamse, & Verwey, 2011). To examine whether sequence learning in the DSP task also yields associative learning in younger people – in parallel to motor chunk development – Verwey and Abrahamse (2012) had young adults practice two 6-key sequences in the normal DSP task way. In the ensuing test phase, these participants were kept from using motor chunks by introducing in 75% of the sequences, stimuli at two random positions that deviated from the learned order. As a result they were forced to react to all movement-specific stimuli again. As expected the execution rate of the occasional sequences in this condition that did not include these deviants was lower than when these sequences were produced in a condition without such deviants. More importantly, execution rate was still higher than that of comparable sequences that were unfamiliar. Verwey and Abrahamse (2012) argued that the possibility that deviants would occur kept participants from using motor chunks. Still, these participants did benefit from the associations that had developed in parallel with the motor chunks. This account was supported by the observation that the RT distributions in these familiar sequences were shifted as a whole relative to those obtained with the pure-familiar and unfamiliar sequences, but they had not widened. So, the faster execution rate could not be explained by participants alternating the chunking and reaction modes.

One may wonder whether the associations assumed to underlie associative sequence learning are independent of the chunking mechanism. It is possible that the same associations underlie associative sequence learning and motor chunk development, and that the difference is merely whether or not successively selected movements are first temporarily buffered in the chunking mode, or are immediately executed one after the other in the associative mode. If so, associative sequence learning may not develop if during practice the use of motor chunks is prevented and participants continue to perform the sequences in the reaction mode. In contrast, the notion that associative sequence learning involves independent mechanisms at the perceptual, central, and motor levels of information processing (Abrahamse et al., 2010; Goschke & Bolte, 2012) predicts that associative sequence learning can develop even when motor chunks do not.

To explore whether associative sequence learning and motor chunk development involve independent sequence learning mechanisms, we designed a study in which participants in the deviant practice group practiced two 6-key DSP sequences that always contained one deviating stimulus. This deviating stimulus was determined randomly for each trial, and could occur at any location except the first. It forced participants to continue reacting to individual stimuli while practicing the sequences. They were not able to use motor chunks because they never executed the underlying base sequence without deviant during

practice. Nevertheless, the findings of sequence learning in probabilistic versions of the serial RT task (Abrahamse et al., 2010) suggested that in this condition sequential associations could still develop. With this setup we tested whether associative sequence learning develops in case motor chunks cannot be used, and whether the development of associative sequence learning may perhaps still allow the later use of motor chunks. To assess performance in a condition in which motor chunks do develop, the non-deviant practice group practiced the same two sequences without deviants, that is, the base sequences themselves.

The notion that associations develop in the deviant practice group predicts that when deviants do not occur anymore in a subsequent test condition, the deviant practice group should be faster on the base sequence (that they actually never encountered during practice) than on an entirely unfamiliar sequence. Yet, they should still be slower than the non-deviant practice group because they did not develop the required motor chunks, while the non-deviant practice participants did.

A further research issue concerned whether prior experience with the associative mode (in the deviant practice group) or chunking mode (in the non-deviant practice group) influences the execution of unfamiliar sequences. To examine this, we also introduced a random test condition. In this random condition, each stimulus was randomly selected during runtime (though preventing repetitions) so that there was no fixed order at all. This condition allowed us to assess response times in case there is no fixed order, that is, in a pure reaction mode. This condition served as baseline to see whether participants improve on the unfamiliar, fixed sequences in the course of a single test block. If prior experience with a particular mode helps using that mode with unfamiliar sequences, one can expect the deviant practice group (that extensively used the reaction mode during practice) to be faster on random sequences in the test phase than the non-deviant practice group (that had been using the chunking mode during practice). Conversely, non-deviant practice group participants may be faster in unfamiliar but fixed sequences that allow a quick use of the chunking mode. The potential finding of a group by sequencing mode interaction would support the notion that people can develop a general skill in using the associative or the chunking mode—even in a sequence that is unfamiliar.

In short, the present study addressed if a) associative learning develops even when motor chunks are not used during practice, b) such associations may still allow the subsequent use of the chunking mode, and c) experience with a particular execution mode may facilitate later use of the mode.

2. Method

2.1. Participants

Forty-eight undergraduate students took part in exchange for course credits (average age: 20.9, age range: 17–25 years, 24 women). The study was approved by the ethics committee of the Faculty of Behavioral Sciences of the University of Twente.

2.2. Apparatus

Stimulus presentation, timing, and data collection were achieved using the E-prime© 2.0 experimental software package on a standard Pentium© IV Windows XP© PC. Unnecessary Windows services were shut down to improve RT measurement accuracy. Stimuli were presented on a 17 inch Philips 107T5 display running at 640 by 480 pixel resolution in 16 bit color, and refreshing at 85 Hz. The viewing distance was approximately 50 cm, but this was not strictly controlled.

2.3. Task, sequences and stimuli

Six black 9 × 9 mm placeholders were displayed on a computer display with a white background. Between each placeholder there was a

Download English Version:

<https://daneshyari.com/en/article/7277526>

Download Persian Version:

<https://daneshyari.com/article/7277526>

[Daneshyari.com](https://daneshyari.com)