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Interactions of Declarative and Procedural Memory in Real-Life Tasks: Validating CPR as a New Paradigm

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Introduction

In the learning and memory literature, there is a clear distinction between procedural and declarative memory. We know that they develop differently in children (Finn et al., 2016) and that they are dissociated anatomically and this distinction is reflected in cognitive architectures as well (Anderson et al., 2004). In the lab, most tasks tap into and measure either one of those components. In most complex real-life skills, however, both declarative and procedural memory are required to perform well.

Here we will look at the learning of a complex real-life skill: cardiopulmonary resuscitation (CPR). More specifically, we will teach participants *basic life support* skills meant to be performed on an adult victim suffering from cardiac arrest. CPR has both declarative and procedural components and there are clear guidelines prescribing the sequence of steps that need to be executed (Perkins et al., 2015). This sequence needs to be remembered (e.g., *I need to call am ambulance* before *I initiate CPR*) which draws on declarative memory. Learning to administer correct compressions, on the other hand, is probably closer to a procedural skill.

CPR is an ideal task for various reasons. It is clearly constrained and can be performed and monitored in a controlled (lab) environment while staying close to how it would be trained in a real-life setting. Publicly accessible guidelines provide clear learning criteria against which the obtained measures can be compared. The skill can be learned in a single session and pilot data suggest that there are individual differences in how quickly CPR performance decreases after initial learning and that not all aspects of CPR are retained equally well. Therefore, CPR is an ideal testbed to investigate the interaction between declarative and procedural learning in a real-life setting. In this exploratory study, we will investigate which aspects of CPR performance are best predicted by someone's declarative learning or procedural learning ability.

Tasks

To address the research question, we will have each participant perform three tasks. Each task is intended to measure one of the three components of interest: acquisition and performance of CPR, procedural learning, and declarative learning.

Learning CPR

Each participant is taught "adult basic life support" skills in accordance with the guidelines of the European Resuscitation Council (Perkins et al., 2015). Hereto, participants watch an instructional video and then practice CPR with a Laerdal Resusci Anne QCPR manikin. Data is recorded using the Laerdal SimPad SkillReporter. This setup allows detailed recordings of the skill development during the acquisition of basic life support skills: both the order of the steps that were taken can be recorded as well as detailed measures of each compression and rescue breath that is administered. After an initial training phase (with corrective feedback), CPR performance will be assessed about 45 minutes later and either one or four weeks later.

Procedural Learning

To assess a participant's expertise in procedural learning, we selected separate implicit and explicit procedural knowledge tasks.

Serial Reaction Time Task. In the serial reaction time task (SRTT) visual cues appear over four response options and the participant needs to respond with one of four fingers that are mapped to the response options. The task can be used as a measure of implicit procedural learning by presenting the participant with different blocks of trials: one block in which the order of responses is random and one in which the order is a repeating sequence (Robertson, 2007). The participant is (usually) not aware of the sequence but their reaction times become markedly faster. A learning measure can be computed by subtracting the mean reaction time in the sequenced block from the mean in the random block (e.g., Willingham, Salidis, & Gabrieli, 2002).

Mirror Tracing. In the mirror tracing task, the participant sees a line with 12 corners connecting two points and needs to trace the line. However, they can only see the line and their own hand through a mirror. With practice, both the completion time and the number of errors decreases, indicating procedural learning. Quantifying the improvement provides a learning measure that is linked to individual differences (e.g., Finn et al., 2016).

Declarative Learning

To derive a learning measure for someone's ability to learn declarative information, we use a fact learning system developed in our lab. The system uses retrieval practice to quiz learners on a trial-by-trial basis. This allows recordings of accuracy and response latencies which are used to estimate the current memory strength of the test item, which are used to schedule a repetition of the item before it is forgotten (Van Rijn, van Maanen, & van Woudenberg, 2009). As more information is gathered, an estimate of how quickly an item is forgotten is fine-tuned. After studying 35 Swahili-English word-pairs for 15 minutes, an estimated rate of forgetting can be obtained for each participant. This learning measure indicates how quickly, on average, a participant forgets this type of material. We have shown that this measure can be measured reliably (Sense, Behrens, Meijer, & Van Rijn, 2016) and is not related to common measures of executive attentional functioning (Sense, Meijer, & Van Rijn, accepted).

Procedure

A total of 40 participants with no prior CPR experience will be invited to participate. So far, data from 20 participants has been collected. Participants will be invited for two sessions. In the first, they will be taught CPR and will complete the 15-minute word-learning session, 768 trials of the SRTT (half random, half sequenced), and nine mirror-tracing trials. At the end of session one, they will be tested on the CPR performance. Either one or four weeks later, in session two, participants will be tested on the Swahili words they learned as well as on their CPR performance. Also, they will complete another round of 768 SRTT and nine mirror-tracing trials.

Planned Analyses

This is an exploratory study to verify whether the acquisition and forgetting of CPR skills can be captured in this paradigm and how CPR performance is related to established declarative and procedural learning tasks.

The computation of learning measures for the declarative and procedural tasks is straightforward, however, valid measures for CPR still need to be developed. As a large number of measures are recorded, the main challenge will be to construct suitable learning measures. We will report a first exploration of various options and discuss their merits.

The derived learning measures can then be correlated with the learning measures for the declarative and procedural tasks. Multiple regression can be used to determine which (combination of) measures can best explain variance in overall CPR performance. Furthermore, we will look at which aspects of CPR are forgotten more quickly than others and lead to a decrease in overall CPR performance.

Hopefully, this project will provide useful information with regards to CPR's relationship to declarative and procedural learning as well as indications that might be helpful to optimize (re-)learning of CPR. Furthermore, steps will be taken to establish CPR as a complex real-life task that involves both declarative and procedural components. As such, modeling human behavior in this task can shed more light on the relative contributions of declarative knowledge and procedural skills in complex human behavior.

References

Anderson, J. R., Bothell, D., Byrne, M. D., Douglass, S., Lebiere, C., & Qin, Y. (2004). An integrated theory of the mind. *Psychological Review*, *111*(4), 1036–60.

Finn, A. S., Kalra, P. B., Goetz, C., Leonard, J. A., Sheridan, M. A., & Gabrieli, J. D. E. (2016). Developmental dissociation between the maturation of procedural memory and declarative memory. *Journal of Experimental Child Psychology*, *142*, 212–220.

Perkins, G. D., Handley, A. J., Koster, R. W., Castrén, M., Smyth, M. A., Olasveengen, T., … Greif, R. (2015). European Resuscitation Council Guidelines for Resuscitation 2015. Section 2. Adult basic life support and automated external defibrillation. *Resuscitation*, *95*, 81–99.

Robertson, E. M. (2007). The Serial Reaction Time Task: Implicit Motor Skill Learning? *The Journal of Neuroscience*, *27*(38), 10073–10075.

Sense, F., Behrens, F., Meijer, R. R., & Van Rijn, H. (2016). An Individual's Rate of Forgetting is Stable over Time, but Differs Across Materials. *Topics in Cognitive Science*, *8*(1), 305–321.

Sense, F., Meijer, R. R., & Van Rijn, H. (accepted). On the Link between Fact Learning and General Cognitive Ability. In *Proceedings of the 38th Annual Meeting of the Cognitive Science Society*.

Van Rijn, H., van Maanen, L., & van Woudenberg, M. (2009). Passing the test: Improving learning gains by balancing spacing and testing effects. In *Proceedings of the 9th International Conference on Cognitive Modeling* (pp. 110–115).

Willingham, D. B., Salidis, J., & Gabrieli, J. D. E. (2002). Direct comparison of neural systems mediating conscious and unconscious skill learning. *Journal of Neurophysiology*, *88*(3), 1451–1460.