

# Cognitive Modelling of Drawing Diagrams from Memory

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**Abstract.** Are perceptual chunks in memory central to the process of drawing? This study will analyse participant’s response data of drawing diagrams of different levels of complexity to explore in what circumstances chunks are used or not. We will also build ACT-R models to understand the mechanisms of how chunking is involved in each stage of the drawing from memory process.

**Keywords:** Drawing diagrams · perceptual chunks · chunking · ACT-R.

## 1 Introduction

There is a large literature on how people perceive and reason with diagram. In contrast, drawing diagrams has been rather neglected but its importance is shown in studies in cognitive science [5–7]. Therefore, this research aims to understand how people draw diagrams from memory, with a particular focus on understanding the strategies and internal representations they use.

One way to build up efficient internal representation is chunking. Chunking, a fundamental explanatory concept in cognitive science, is a mechanism that collects associated information into groups, which can greatly reduce our cognitive effort to hold and recall relatively long streams of information. Of particular interest is whether chunking has a central role in drawing. We will investigate in what circumstances people use chunking and when they do not, as well as how perceptual chunks in memory are involved in drawing strategies. The diagrams of different levels of complexity used in this study are shown in Fig. 1.

## 2 The approach being taken

We will investigate the existence of chunking and how they guide the drawing process by analysing the pauses and the spatial features, such as proximity and closure Gestalt patterns, of participant’s drawing actions. The pause, or latency, between two successive actions can reflect the structure of perceptual chunks in memory [6]. A relatively long

pause can indicate the boundary between the processing of successive chunks, because there are additional retrieval and planning processes required to start processing information in a new chunk. The spatial features can suggest the

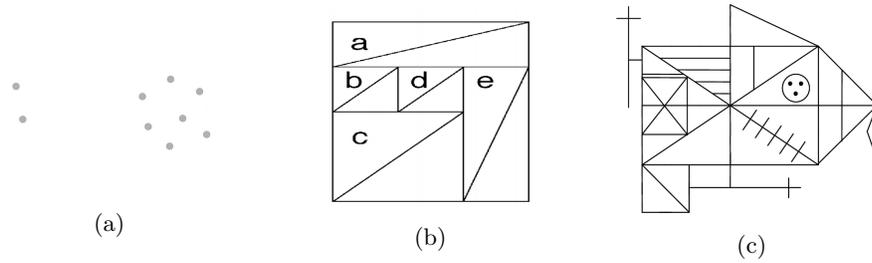


Fig. 1: Three plots with different drawing complexity levels: (a) a very simple plot constructed by dots, (b) an AVOW (Amps, Volts, Ohms, Watts) diagram representing electrical circuits [2], (c) a Rey-Osterrieth Complex Figure [5].

existence of chunking as well, because humans can naturally use Euclidean geometric patterns to encode visuospatial sequences which can effectively reduce the complexity of stimuli and task.

To further understand the mechanisms of chunking, we will build ACT-R (Adaptive Control of Thought—Rational) models to simulate the drawing strategies found in analyses. ACT-R is an integrated cognitive architecture which was developed based on finding from cognitive psychology and brain imaging experiments [1]. With ACT-R, we can build models of our findings to simulate a participant’s responses. By comparing the quantitative measures (such as reaction time) provided by the ACT-R models with participants’ actual response data, we can examine what plausible strategies match with actual response data.

### 3 Completed Work

We started from a basic drawing task, in which patterns of dots (shown as Fig. 1a) are viewed with various exposure durations and reproduced, to explore whether there are strategies that do not exploit chunking.

Our hypothesis is that when dots are presented with a short exposure time ( $\leq 200$ ms), people may simply hold those dots in their visuospatial working memory and then pick dots to reproduce. This approach will be inaccurate with a large number of elements or when the image in the visuospatial working memory fades. If sufficient time is given ( $> 1$ s), people will start to build up chunks in short term memory to enhance their memory for the target dots.

We re-analysed data from two experiments conducted by Haladjian and Mathy [4] to verify our hypothesis. Chunking was evident with long stimuli exposure times but not with short ones. With more opportunity to chunk, various temporal and spatial signals suggest the occurrence of chunking, including: pauses between actions are longer with long exposure than with short exposure; actions are temporally clustering into groups with sizes of typical chunks; spatial locations of responses are sometimes clustered as simple geometric shapes; clusters of responses are more likely to occur at the start or end of trials

Another interesting result is a template-like structure [3] which was found in participants' responses. The templates were formed by associating a core geometry pattern with some additional nearby dots (e.g., a square with a dot inside). This result indicated the existence of constructing hierarchical representations even in this simple transcription drawing task of simply plotting sets of dots and supported previous studies that the drawing is a hierarchical process.

## 4 Expected contribution

The purpose of this study is to understand the nature of drawing diagrams more clearly. Building ACT-R models can not only give the chunking strategies found in analyses a psychologically plausible verification, but also help us understand the detailed mechanisms of how perceptual chunks are involved in drawing.

By analysing the participant's response data, we can understand when will people use chunking and when not. Our first analysis shows that if the exposure time of stimulus is too short, people may not have time to do the chunking processes, they will only use the visual-spatial working memory.

Another expected contribution is that we test whether ACT-R has the ability to build drawing models, because originally ACT-R was not built to model this type of task. If we do not need to add major new functions, then it means ACT-R can model the drawing diagram processes. Whereas, if we need to add functions, then the functions can show how ACT-R could be improved.

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