ABSTRACT

Semantic category learning through explicit and implicit knowledge of complex sequences

Objects with similar functions are judged to be similar "kinds of things," even when they have few directly-observable properties in common. How do people learn such "functional" similarity? One possibility is that objects with similar functions occur in similar contexts: there is overlap in the sequence of events that precede and follow their use. To test this hypothesis, participants learnt a novel sequence with multiple interchangeable objects at each position and subsequently were taught to name the objects. As expected, participants learnt category structures consistent with the positions in the sequence. However, contrary to hypothesis, this learning did not transfer to naming and participants did not learn names consistent with the category structure more quickly than random names. Interestingly, an interaction between naming condition (consistent and random) and learning (participants who learned the sequence and participants who did not) was found also and warrants further investigation.

Annabel Li, Genetics and Psychology
Author Name/Major

Author Signature

Timothy Rogers, Psychology
Mentor Name/Department

Mentor Signature

_May 20, 2009___
Date

COVER SHEET

TITLE: _Semantic category learning through explicit and implicit sequence learning

AUTHOR'S NAME:_____Annabel Jerry Li___________________________

MAJOR: ____Genetics and Psychology________________________________

DEPARTMENT: ____Psychology__________________________

MENTOR: ____Timothy Rogers_______________________________________

DEPARTMENT:_______Psychology___________________________________

MENTOR(2): ____

DEPARTMENT(2):____

YEAR: ____2009____

(The following statement must be included if you want your paper included in the library's electronic repository.)

Semantic category learning through explicit and implicit knowledge of complex sequences

Introduction

A central goal of cognitive psychology is to understand how we learn to categorize objects—that is, how we discern which items in our environment should be treated as the "same kind of thing" for purposes of naming, action...etc. It is not always physical similarities that prompt us to group objects together; often, we seem to categorize by function. For example, when asked to group two of three objects—pencil, typewriter and straw—people tend to group pencil and typewriter, although the physical appearance of a pencil is much closer to a straw, presumably because the pencil and typewriter have similar functions. How do we learn to categorize by function as opposed to physical similarity?

One hypothesis is that we learn from knowledge of the sequence of events in which objects participate. For instance, when writing a letter one might: 1) take a piece of paper, 2) write the letter using either a pencil or a typewriter, 3) put the letter in an envelope and mail it. In this situation, the events leading up to the use of the pencil or typewriter are identical, as are the events that follow the item's use. That is, the typewriter or pencil can be used interchangeably in the task sequence. Perhaps we learn that items are "functionally related" when they can be used interchangeably within well-known event sequences like letter-writing.

This hypothesis has never been tested directly, but there are some clues in the literature that it may have merit. For instance, Cleeremans and McClelland (1991; 1993) showed that people can learn the abstract "rules" or grammar underlying complex sequence patterns in a simple button-pressing task. In the experiment, the task was to quickly and accurately press one of six keys on a keyboard when a stimulus appears in the corresponding position on a computer display. Subjects were told that the appearance of stimuli was random, but unbeknownst to them, most of the trials were not; a set of rules determined the position of the stimulus depending on its position in the previous trial, and only in 15% of trials did the stimulus appear in a truly random position. It was found that over time, the average reaction time (time between when the stimulus appeared and the pressing of the correct key by the subject) decreased, an expected result due simply to practice. More interesting is the fact that the gap in reaction time between random and non-random (following the set of rules) trials also became larger and larger. This shows that subjects learnt something about the pattern—that they could 'predict' where the stimulus would appear next, making it possible for them to react faster in a trial that followed the rules compared to a trial that was completely random. Furthermore, this learning generalized to new sequence patterns that conformed to the "grammar," but which participants had not previously seen.

This and many subsequent studies show that people can learn productive "rules" underlying complex sequence patterns, but these demonstrations do not bear directly on the current research questions for three reasons. First, no study has investigated how sequence-learning influences categorization of the elements that participate in the sequence. Second, no study has investigated how sequence learning influences performance on clearly semantic tasks such as naming. Third, the learning investigated in past work is *implicit motor learning*, that is, it influences speed and accuracy of certain motor actions (button pressing), without conscious awareness. It is not clear whether such "procedural" learning would have any impact on semantic category learning, which is typically thought to involve explicit, propositional or "declarative" knowledge about category relationships. To determine whether semantic category learning can be influenced by knowledge of event sequences, therefore, it is important to investigate both explicit and implicit sequence learning.

This thesis project aims to address these issues by investigating: 1) how objects encountered within a sequence-learning task get categorized in the performance of the task, and 2) whether categories learned within the sequencing task influence learning in a subsequent semantic-categorization task. It is hypothesized that participants will categorize objects according to its position in the learnt sequence and that this categorization will transfer over to a semantic task such as naming. Further work will be done to look at whether these learned categories differ when the sequencing task is learned implicitly versus explicitly.

Method

Two experiments were done: Experiment 1 and Experiment 2. Experiment 2 was identical to Experiment 1 except that a naming pre-test was done, assignment of symbols to spots in the sequence was counter-balanced, and sessions were at different times during the day instead of strictly at 8am and 8pm. Experiment 2 (still ongoing) will be described below unless stated otherwise.

Participants

54 students at UW-Madison participated in the study (Experiment 1 and Experiment 2 combined), and were screened to ensure they do not recognize Chinese or Japanese Kanji characters. Participants were either paid a total of $50 for full participation or awarded extra credit in introductory psychology.

Design

A between subjects design was used for the two conditions: consistent and random naming (see description of the Naming Game).

Materials

PowerPoint Presentation

The PowerPoint presented basic information about the 'premonition game' to participants, including the instructions for the game: "click on the tile that you believe is the correct target". No additional clues for finding the correct target were given, and the word 'sequence' was never mentioned.

Premonition Game

The goal of the premonition game was to allow participants to learn by trial and error a novel sequence without the involvement of implicit motor learning, and assess whether they subsequently categorize the objects involved according to their position in the sequence (learn the 'category structure') by using these categories to generalize within the sequential task. The game was played on a computer.

The sequence to be learnt had 6 positions (or categories) which rotated in order in a loop (1-2-3-4-5-6-1-2-3 ...etc). Each position had multiple interchangeable objects, represented by Chinese characters in the game, and referred to as symbols A – O from here on. Thus, if we are at position 1, either symbol A or B would be correct (see fig. 1). We would then move on to position 2 where symbols C, D, or E would be correct. In other words, the A →C, A →D, A →E transitions as well as the B →C, B →D, B →E transitions are all correct. Assignment of Chinese characters to spots in the sequence was counterbalanced.

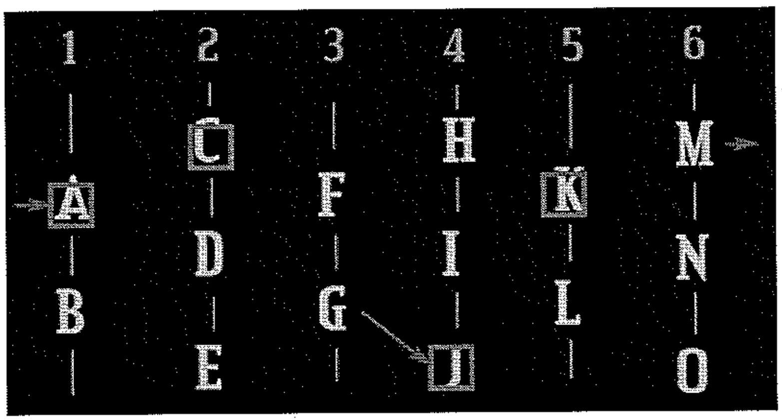

Figure 1. *A diagram showing the complete sequence and the symbols at each position. During sessions 2-5, the symbols marked with a green square never follow a trial with G or M as the target. During the last session this restriction is lifted and participants' ability to use the categories to generalize within the*

In the actual game interface, there was only one correct choice at any given time: i.e. when the game is at position 1, either A or B was shown but never both. On each trial where the participant had to choose the correct symbol, there were always 4 symbols shown: 1 correct "target" symbol and 3 other incorrect distracter symbols chosen randomly (with one exception explained below), and the locations of each on the screen was random. If the participant picked the correct symbol, the game immediately moved on to the next trial. If the participant picked incorrectly, the correct symbol would light up, but the participant had to wait 3 seconds before they could move on to the next trial. Each session consisted of 12 rounds of the game, each with 100 trials.

The one exception to the random selection of the 1 target and 3 distracter symbols for each trial was that during sessions 2-5, symbols A, C, J and K never appeared on a trial following one that had G or M as the correct 'target' symbol. This was done so that participants would never be directly taught that the G →J and M →A transitions were correct nor taught that the G →A, M →K …etc transitions were incorrect. We used this to assess whether participants can generalize using the categorical structure by introducing during the last session trials with A, C, J and K as the 4 choices following trials in which G or M were the targets. If participants were able to generalize, they should correctly make the G →J and M →A transitions. This arrangement also ruled out the possibility of an elimination strategy during these special trials during the last session, because participants have never been taught that the other transitions are incorrect.

<u>Naming Game</u>
Both games were played on a computer.

Pre-test Naming Game: One symbol was shown on the screen at a time, surrounded by six names. The participant had to choose the correct name for the symbol, and learnt the correct names by trial and error (when they chose incorrectly, the correct name was revealed to them). The criterion was 20 correct naming in a row; when participants reached that they finished the game. The 12 symbols used were also Chinese characters, but different from those used in the Premonition Game. The purpose of the pre-test was to assess individual differences in ability to complete a naming task.

Post-test Naming Game: The post-test naming game was identical to the pre-test naming game with the exception that the 12 symbols used were the Chinese characters from the Premonition Game, with omission of C, H and M. The two conditions, consistent (symbols in the same position in the sequence were given the same name) and random (random assignment of names), allowed us to assess how knowledge of the categories from the Premonition Game transfers to a semantic task such as naming, as it can be expected that participants would be faster at learning when the names were consistent than when they are random.

<u>Naming Questionnaire</u>
The naming questionnaire was paper-based and has three items. Each showed a symbol with the six choices of names from the Naming Game below it, and the participant has to circle the name that he/she believes to be correct for the symbol shown. The three symbols were C, H and M, which were omitted from the post-test Naming Game, and the correct name is the name given to the other symbols in their category (i.e. for C, the correct name is the name given to D and E in the naming game). Since participants were never directly taught the names of C, H and M, if they are able to name them correctly, it shows that they were able to use the categories to generalize their knowledge of names as well.

Procedure

The full study consisted of 6 sessions, each one hour long, at various times during the day. The sessions spanned at least 3 days and with at least 4 hours between sessions.

Session 1: Participants were introduced to the study and completed a consent form and a demographics form. They then played the pre-test 'naming game' with instructions to "choose the correct name for the symbol you see on the screen"

Sessions 2-5: Participants viewed the PowerPoint presentation then proceeded to playing the 'premonition game'.

Session 6: Participants played the 'premonition game' with G →J and M →A transitions, followed by the post-test 'naming game' and lastly, filled out the naming questionnaire.

Results

Results reported here were collected from Experiment 1. As expected, it was found that participants were able to generalize according to the categorical structure within the Premonition Game. During the last session, participants made the correct G →J (M = 0.75, SD = 0.21) and M →A (M = 0.83, SD = 0.25) transitions at a rate significantly above chance. However, the transfer of this knowledge to the semantic naming task did not reach significance. Participants who learnt the consistent names (M = 158.3, SD = 71.7) in the post-test Naming Game did not reach criterion faster than participants who learnt random names (M = 141.5, SD = 79.0).

When the participants were split into 'learners' (reached a 0.66 or higher accuracy rate by the last session in the Premonition Game) and 'non-learners' (did not reach the 0.66 accuracy rate), an interaction between learning ('learners' and 'non-learners') and naming condition (consistent and random) was found (fig. 2). When names were consistent with the categories, participants took less trials to reach criterion when they learnt the sequence than when they did not. When names were random however, participants took more trials to reach criterion when they learnt the sequence well.

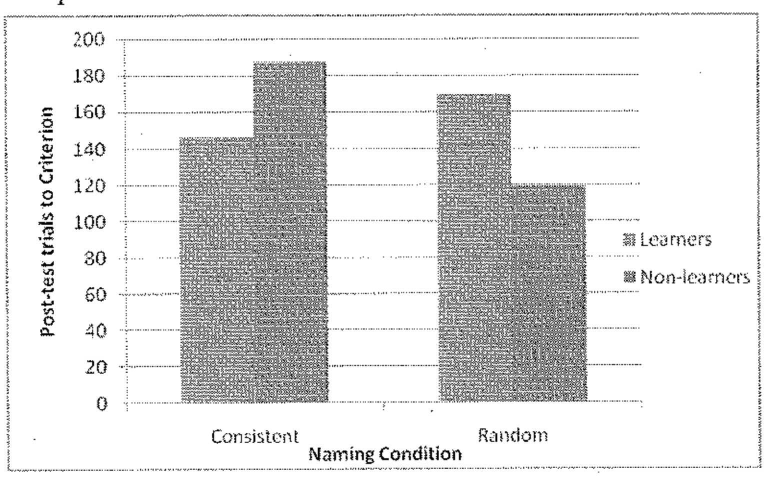

Figure 2. *There was an interaction between naming condition (consistent and random) and learning (learners and non-learners).*

Lastly, contrary to hypothesis, participants did not generalize names according to the categorical structure. Participants did not correctly name symbols C, H, and M at a rate above chance in the Naming Questionnaire.

Discussion

It was hypothesized that participants would categorize objects according to its position in a learnt sequence and that this categorization would transfer over to a semantic task such as naming. It was found that participants did indeed categorize according to a symbol's position within the Premonition Game (as shown by generalization to correctly make the G →J and M →A transitions), but this categorical knowledge did not mean fewer numbers of trials were needed to learn consistent names compared to random names. The lack of effect however could likely have been due to huge individual differences in the ability to learn names which would greatly affect the time required to complete the naming game, completely hiding a significant effect. Data from control participants who completed only the naming task showed a huge standard deviation almost half of the mean ($M = 248.6$, $SD = 110.7$) and support this hypothesis. This problem has been addressed in the still ongoing Experiment 2, where the pre-test naming game assesses participants' inherent ability for naming so this can be taken into account when looking at the data from the post-test naming game.

Further support for the notion that transfer of categorical knowledge to naming occurred but simply was hidden in the data comes from the finding of an interesting interaction between naming condition and learning. When names were consistent with the categories, participants took fewer trials to reach criterion if they learnt the sequence well than when they did not, but the reverse was true when the names were random. This suggests that knowledge of the sequence does affect the learning of names and that it was not a null effect that caused the lack of transfer. This interaction is interesting in its own right however, as it seems to show that knowledge of the sequence interferes and has a detrimental effect when names were random. This could be an important clue to how categories are formed, and definitely deserves further attention.

Future directions include further investigation of the interaction found, and exploration of the effect of explicit vs. implicit sequential knowledge.