THE EFFECTS OF STUDY AND TEST VARIABLES ON MEMORY

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ABSTRACT

Do different conditions and methods of presentation affect the likelihood of eliciting false memories? We divided subjects into groups of three to eight and presented them with lists of associated words. We tested them to observe how accurately they could recall the studied words, and how often they recalled related but not studied words ("false memories"). Half of the groups were tested individually, and the other half was tested collaboratively. All groups were presented with the same four lists, but with different rates and modalities. In our collected data, we found that all four of our variables (sex, rate, modality, and testing conditions) affected false memories. The results were analyzed in regards to reducing false memory in real life.

INTRODUCTION

Memory is a fairly broad term that people understand to be one's ability to recall, remember, and recognize past events and information. Whether it be recalling where one put his or her car keys or testifying in a courtroom, people always find themselves attempting to recall past events. Although most agree that a good memory is a desired trait, many do not make an attempt to define "good" or "bad" when speaking of memory. The common notion is that forgetfulness defines bad memory, but psychologists do not limit the concept of bad memory to forgetfulness alone. In addition to forgetting previous occurrences, bad memory is reflected in remembering events that in fact never occurred, or remembering them very differently from how they did occur [1]. What makes people remember incorrect information and how often does this occur? Can we prevent this potentially harmful phenomenon?

While forgetting has been systematically studied since the late 1800's (starting with Ebbingaus [2]), Bartlett [3] generally receives credit for being the first to investigate false memories. He had subjects read an oddly written Native American folk tale and repeatedly attempt to recall it. He found distortions in their re-telling of the story suggesting that they filled in details with their own memories of Native Americans [4]. Another early demonstration of false memories, though at the time they didn't call it that, was reported by Carmichael, Hogan, and Walters [5]. They had subjects study ambiguously drawn simple objects that could be interpreted as more than 1 object (i.e., two circles connected by a short horizontal line was labeled as either eye glasses or a bar bell). Depending on the label provided when studying the drawings, subjects drew from memory the picture distorted toward that label (e.g. if initially labeled as bar bell, the horizontal line was drawn longer and straight, if labeled as eye glasses the horizontal line was drawn short and curved; [6]). Despite these early examples, real interest in false memories did not start until the early

1970's. In general, subjects in these experiments received information to study and they were then later asked to retrieve what they could. The information the subjects were asked to remember typically included sentences [7]; [8], passages of prose [9], sequences of slides [10], or videotapes ([11]; as cited in [12]). Typically subjects recalled false information along with the correct information no matter which method of testing was used, although different methods did induce varying amounts of false memory.

One particularly simple method that produces frequent false memories uses simple lists of associated words [13]; as cited in [12]. These lists of words are generated by collecting the top 15 associates to one particular "critical missing" word and presenting them for study (see Methods and Appendix A for examples). For example, studying the top 15 associates to the word Sleep often results in subjects falsely recalling or recognizing the word Sleep as a studied word when in fact it was not studied. It is believed that these lists elicit the recollection of the critical words because human memory is based on associative processes (an idea first propagated by Ebbinghaus, [2]. People remember information by associating it with other information. In the case that the information that one desires to remember is a word, it is common to remember that word through its synonyms or antonyms. False memory occurs primarily because the human mind attempts to remember by using associative techniques.

Since the preliminary findings reported in Roediger & McDermott [12], a number of studies have been published exploring what influences the likelihood of subjects having these false memories, and what can be done to minimize them. For example, it has been shown that older adults and adults with dementia of the Alzheimer's type are far more likely to have false memories than healthy younger adults [14]. One study even went so far as to inform the subjects about the false memory phenomenon and warned the subjects against having them. Despite this warning, subjects still falsely recalled the critical non-presented words [15].

In the present experiment, we focused on four specific variables that might influence the likelihood of having false memories. This was accomplished through the Deese-Roediger-McDermott (DRM) method in which subjects are presented with a list of related words and then later asked to recall them.

One variable of interest is the modality in which the lists of words were presented. Smith and Hunt [16] have shown that visual presentation, compared to auditory presentation, reduces the likelihood of false memories [17]. They argued that visual presentation leaves a stronger impression of the actual studied words, enabling subjects to better reject false memories of having studied the critical missing words. In contrast, Maylor and Mo [18] found more false recognition with the visual presentation. We hope to add additional evidence to this question to help resolve which is correct.

Another variable of interest is how quickly the lists of words are presented. According to Toglia and Neuschat's [19] study, a faster presentation increases the probability of false recall. However, other researchers have also shown that decreasing the presentation rate consequently decreases the likelihood of false recall [17]. Here again we discover

contradictory findings. One argument suggests that a longer display time would cause subjects to more deeply encode the theme of the list and therefore make them more likely to falsely remember the missing word which in effect represents the theme of the list. On the other hand, it has been argued that when the list of words is presented very quickly, subjects have little time to accurately encode the actual words and are only left with the theme of the list. Thus, fast presentation is likely to result in more false memories.

In addition to these two manipulations of the study conditions, we were also interested in how the testing conditions might influence the likelihood of false memories. Weldon and Bellinger [20] reported findings suggesting that when subjects work in groups to collaboratively recall studied materials, they do better than when they are given the opportunity to recall individually. What is not known is what effect this will have on false memories.

The final variable of interest is the sex of the participants. Surprisingly, we found no past studies on the differences between males and females in false memory recall. Past researchers have studied sex differences for true memory recall. One study done by Ionescu [21] found that there were no sex differences and that males and females remembered about the same amount of information. In contrast, another study done by Andersson [22] showed that females displayed better memory than males. Because of the conflicting results we obtained in our research, we attempted to discover which sex would actually perform better.

In summary, we predicted that auditory presentation will lead to more false memories than visual presentation, and that slow presentation (compared to fast) would elicit fewer false memories. We also predicted that collaborative recall would result in better true memory and perhaps more false memory since some subjects may provide words with uncertainty in order to contribute to the group. Finally we had no reason to predict that males would perform any differently from females in either true or false memories. In order to provide definitive results that would verify a direct connection among the manipulated variables and false memory, we executed the experiment described in this report.

METHODS

Subjects

Eighty one students from the 2004 New Jersey Governor's School in the Sciences participated voluntarily. Forty females were tested but the results of four were discarded due to technical difficulties. Forty one males were tested. The participants ranged in age from 15 to 17 years.

Materials

Twelve lists of words from the Stadler, Roediger & McDermott norms [23] were used as study materials. Each list contained 15 words that are the top associates of a critical word that was not presented for study. For example the list for the critical word Rough read: *smooth, bumpy, road, tough, sandpaper, jagged, ready, coarse, uneven, riders, rugged, sand, boards, ground and gravel*. The lists were grouped into four sets of three lists each (45 words per set). Each set had approximately the same average probability of eliciting a false

memory for the critical (non-studied) word. MEL Software [24] loaded on a PC computer attached to a classroom video projector was used to present the sets of words visually at the correct rate and in the correct order. The sets of word lists were also recorded onto a cassette tape for auditory presentation by an adult male who was not familiar to the participants. Lists were recorded onto different tapes at different rates of presentation (quickly and slowly).

Design

The experiment consisted of four test blocks. Each block consisted of one set of words presented for study, followed by a three-minute period in which participants were instructed to write down all the words recalled. The set of words presented in each block were fixed for all subjects in all conditions. Three variables (speed, modality and group or individual) were manipulated to assess their effect on recall of the study lists and recall of the critical missing words (false memories). In addition, the sex of the participants were recorded to assess its effect on recall performance.

Test type was manipulated between-subjects. Thirty eight of the participants were asked to recall the words collaboratively with three to four other participants of the same sex whereas thirty six of the subjects were asked to recall the words individually. Subjects in the collaborative condition were in groups of four to five, one of whom volunteered to be the group recorder and at the time of test wrote down all words the group recalled. Subjects in the individual condition were in groups of three to eight (also of the same sex) and independently wrote down the words they recalled.

The rate and modality of word presentation was manipulated within-subject such that all subjects experienced words presented quickly and slowly, and words presented visually and orally. To accomplish this, rate/modality combinations were manipulated across the four experimental blocks (i.e. one block presented words quickly and orally, another block presented words quickly and visually, etc.). To avoid possible order effects, block condition (e.g. quick-auditory) was counter balanced across groups of participants such that each condition was equally often in blocks one to four (Table 1 for a schematic of the experimental design).

Table 1: Design of the experiment.

Four different group-types were tested, differing in test-type (individual or collaborative) and sex of participant. Each group-type had four sub-groups (A-D) of three to five participants tested at different times. Regardless of group-type, the experiment contained four blocks, and proceeded in the order dictated by the following table:

Sub-group		A	B	C	D
Block 1	List 1	FV	SV	SA	FA
Block 2	List 2	SA	FA	FV	SV
Block 3	List 3	FA	FV	SV	SA
Block 4	List 4	SV	SA	FA	FV

List 1: List for critical words *Smell, Rough, and Anger*. FV- Fast Visual
List 2: List for critical words *Sweet, Chair, and Trash.* SV- Slow Visual
List 3: List for critical words *Doctor, Smoke, and Soft.* FA- Fast Audio
List 4: List for critical words *Window, Needle, and City*. SA- Slow Audio

Procedure

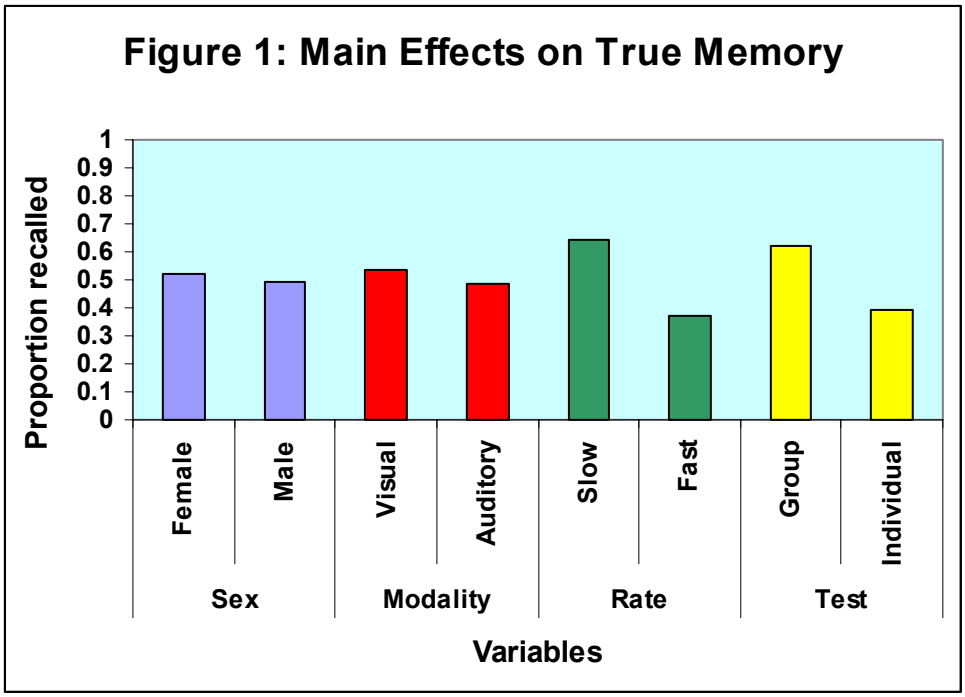
Groups of three to eight subjects arrived at the testing room and were immediately given a consent form in which they agreed to have their responses recorded for research purposes. Afterward, each group of subjects was read the same standardized directions. They were told it was a memory test, but they were not informed of the critical missing words from the study lists. The subjects were given pens and testing packets on which to write their recalled words. Those in the collaborative group selected a person with the neatest writing who was asked to record the group recall. The subjects were instructed to recall the lists independently and were told to refrain from talking to one another or guessing.

When the words were presented quickly, it took .45 seconds per word with .05 seconds in between; the entire "quick presentation" time took a total of 22.5 seconds. When the words were presented slowly, it took 2.5 seconds per word with .5 seconds in between; the entire "slow presentation" took a total of two minutes and fifteen seconds. After the first list of forty-five words was presented, the subjects were given three minutes to recall as many words as possible. When the three minutes were over, the subjects were told to stop writing and turn the page, at which point a new list of forty-five words was presented at a different speed and/or modality. After the second list was presented, they were given another three minutes to recall the words. When the three minutes were over, the procedure was repeated until all four lists were presented and recalled. When the testing session was completed, the testing materials were collected and the subjects were debriefed, but not made aware of the critical missing words. They were told not to discuss the testing as to maintain the integrity of the experiment. The subjects were given candy and/or doughnut munchkins prior to their departure.

RESULTS

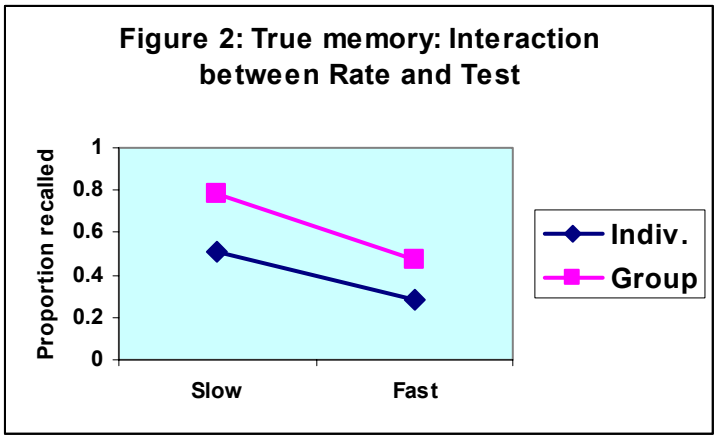
The main goal of this study was to gain insight into the effects that various conditions have on the creation of false memories. The same variables were also analyzed for their effects on the number of true memories and extraneous words recalled. Extraneous words were those that were neither studied nor were the critical missing words. We analyzed the prevalence of true, false, and extraneous memories as a function of the four variables of interest in this experiment: sex of subject, rate of presentation, modality in which words were presented, and test condition. Appendix B contains graphical presentations of all interactions not illustrated in the text.

All of the variables affected true memories (Figure 1).

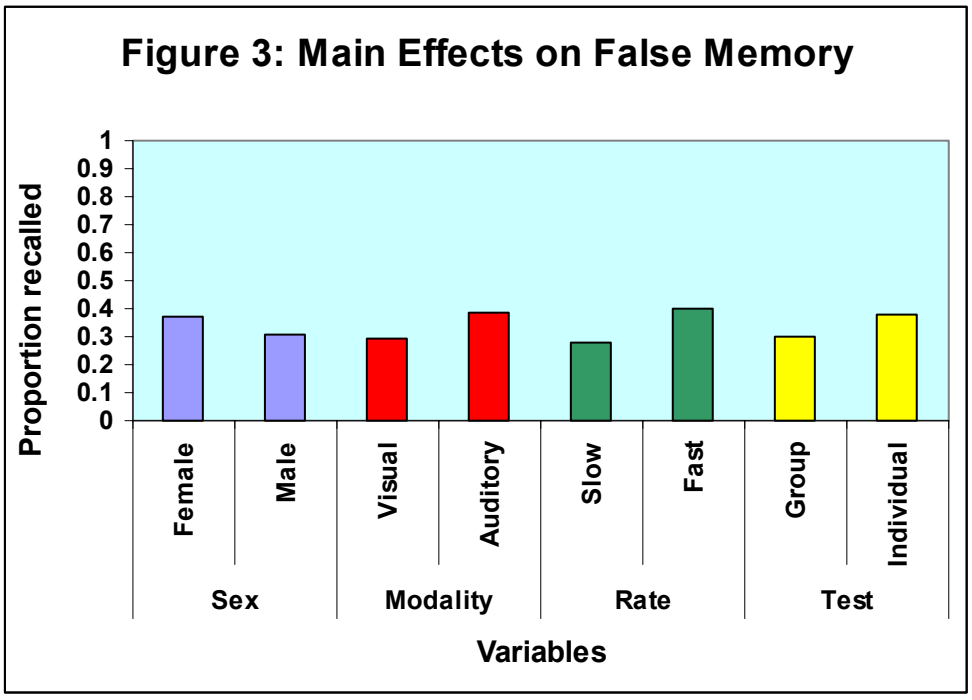


Across all conditions, subjects recalled, on average, 51% of the studied words. While numerically small in difference, the percentage of studied words correctly recalled by females was higher than that of males [0.52 vs. 0.49; $F(1, 73) = 4.03$, $p = 0.048$]. The test condition significantly influenced recall. Subjects working in groups performed better than those being tested individually [0.62 vs. 0.39; $F(1,73) = 323.3$, $p = 0.000$]. Our two study manipulations resulted in significant differences in recall performance such that visually presented words were better recalled than orally presented words [0.53 vs. 0.49; $F(1,73) = 29.3$, $p = 0.000$]. Words presented slowly were better recalled than words presented quickly [0.64 vs. 0.37; $F(1,73) = 773.1$, $p = 0.000$].

In addition, there was a significant interaction between sex of participant and the modality of presentation [$F(1,73) = 4.6$, $p = 0.035$]. Whereas auditory information was recalled about the same for males and females (0.48 vs. 0.49), females recalled significantly more than males when words were presented visually (0.51 vs. 0.56). Rate of presentation and test conditions interacted as well [$F(1,73) = 17.1$, $p = 0.000$]. Rate had a greater impact on true memories for groups than it did for individuals (see Figure 2). No other interactions reached statistical significance.

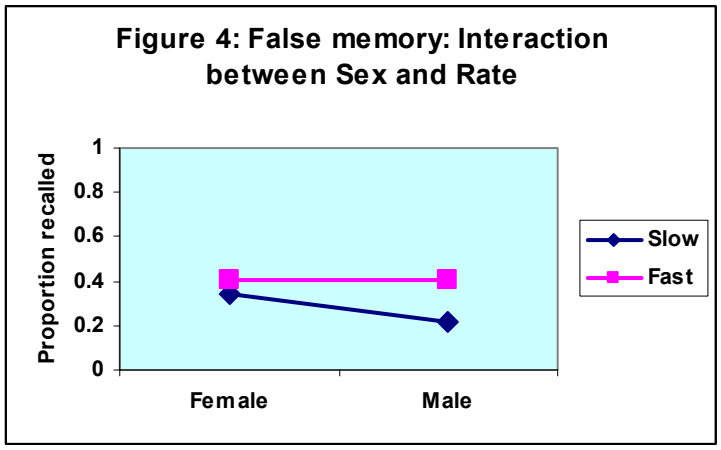


Of greater interest in this investigation was the false recall of the critical missing words. Our attempt to elicit false memories was successful across all conditions (see Figure 3); the probability of false recall averaged 0.34, or about one false word recalled out of every three lists presented. Examining the overall effects of the variables, subjects recalling individually had more false memories than those recalling in groups [0.38 vs. 0.30; F(1.73) = 19.0, p = 0.000]. Similarly, words presented orally led to more false memories than words presented visually [0.39 vs 0.29; F(1,73) = 11.1, p = 0.001]. Words presented quickly elicited more false memories than words presented slowly [0.40 vs. 0.29; F(1,73) = 19.0, p = 0.000].



A number of these main effects that our variables had on false memories were qualified by significant interactions: while the overall difference between females and males (0.37 vs. 0.31) did not reach the traditional level of significance (p = .08), it did significantly interact with rate of presentation [F(1,73) = 5.6, p = 0.021], such that females were more

likely to have false memories when the words were presented slowly than were males (see Figure 4).



Another qualification to the higher incidence of false memories for females was most pronounced when subjects were recalling in groups rather than individually. Test-type also interacted with other variables. It interacted with both the rate of presentation [$F(1,73) = 26.1$, $p = 0.000$] and the modality of presentation [$F(1,73) = 12.0$, $p = 0.001$]. While the amount of false memories differed little between slow and fast presentation when recalling individually (0.39 vs. 0.37), rate had a marked effect when recalling in groups (0.17 vs. 0.44; see Figure 4). With respect to modality of presentation, when tested individually, a similar number of words were remembered when given visually and orally (0.38 vs. 0.38). However, there was a substantial difference when recalling in groups (0.40 vs. 0.21; see Figure 6). No other analyses on the frequency of false memories reached significance.

Finally, we recorded the number of words that were falsely recalled that were not the critical missing word. Overall this number was low, averaging less than 1 word per condition (0.67 words). The rate of presentation interacted with the creation of extraneous memories. More extraneous words were recalled during a fast presentation than during a slow one [0.84 vs 0.50; $F(1,73) = 13.1$, $p = 0.01$]. No other differences were statistically significant.

DISCUSSION

Our study investigated the effects of different variables on eliciting false memories. As predicted, a slow and auditory presentation led to better memory for those words actually studied and fewer false memories. In line with some previously reported findings (but contradictory to others) recalling in groups led to better performance than recalling individually. Groups also were less likely to have false memories. There was some evidence in the literature that females remember better than males but no published findings on sex differences in false memories. Our results suggest that there is a very slight if any difference between males and females for both true and false memories.

A number of psychologists have already experimented with manipulating the rate of presentation. Some reported that faster presentation rate led to more false memories, while others claimed a slower presentation rate led to more false memories. After completing the actual project, our results supported the former. A fast presentation rate likely led to poorer memory for the studied words because it allowed less time for the words to become entrenched in the mind. This might also explain why a fast presentation rate led to more false memories. With poor memory for the actual words studied, subjects might have been left with just the theme or gist of the list, leading them to falsely recall the critical missing word.

Similar to the experiments manipulating the rates of presentation, experiments dealing with modality have produced conflicting results. One experiment argued that visual presentation would produce more false memories than auditory presentation while another experiment suggested otherwise. Our results supported the experiment that led to the greater false recall during the auditory presentation. Poorer memory for studied words presented auditorily might be due to a lack of a visual image of the word. If subjects' ability to recall things is better for visual information we should expect better performance in the visual presentation condition. If auditorily presented information leads to a poorer trace in memory, it might also explain why there were more false memories. Like we found with the fast presentation condition, subjects may have had a strong memory for the theme of the list which would push them to falsely believe the missing word was studied.

We had reason to predict that collaborative recall would lead to better memory for the words studied. With several people all working together to remember the words, all it takes is for one of them to remember a word. Pooling their memories should lead to more recalled words. Similarly, one might predict that group recall would lead to more false memories since it only takes one person to falsely recall the missing word to get it on the list. We actually found the opposite with group recall reporting fewer false memories. This might be because, on the other hand of our previous argument, it only takes one person in the group to catch on to the trick that the critical over-arching theme word was left out of each list and inform the rest of the group. Support for this can be found in the significant interaction between type of test and rate of presentation. When a group is presented with a set of words slowly, the probability for the group to write down a critical word was very low. Perhaps someone remembered a critical word but another group member refuted the word's presence in the list. Consequently, the word would not be written down. This did not occur for the fast condition in the group, because the group did not have time to digest all of the words. The confidence of the individuals in the group was very low, and they weren't positive enough to deny a word's appearance on the list.

Perhaps finding no published reports on sex differences in false memories should have been a clue that such differences do not exist. Although the difference was statistically significant, the actual numerical difference in males and females true recall performance was rather small and likely not particularly meaningful. Though there are reported findings of sex differences in memory, they are typically limited to verbal versus spatial materials. Related to this, there was an interaction between sex and modality of presentation. Male auditory, male visual, and female auditory all elicited about the same percentage of true

memory. However, the percentage of true recall in the female visual group was significantly higher. This may be because women are better visual learners, as compared to men, who can remember things equally well for both modalities.

In general, it is pretty compelling that a group of very smart, alert subjects still falsely recalled about one out of every three critical missing words. Some subjects afterward even claimed to have figured out the purpose of our experiment. Despite this, only one individual out of close to 80 did not write down a single false memory, showing the robustness of this phenomenon. This finding relates to past experiments in which the participants were explicitly warned of the purpose of the test but still had many false memories.

Our lone participant with no false memories highlights how in any experiment there may always be outliers and natural aberrations to deal with. Another outlier was one individual who wrote down seven extra words that were not studied (when the average was less than one). Our large sample size minimized the distorting effect of these cases.

In conclusion, false memory is prevalent for even NJ's finest. This study has shown how we might be able to minimize them. All the variables that showed better results for true memory also had fewer instances of false recall. This may be explained by the fact that if people are able to remember items more specifically, they are less likely to remember extraneous information.

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APPENDIX A: Complete set of all the word lists

Anger List
Mad
Fear
Hate
Rage
Temper
Fury
Ice
Wrath
Happy
Fight
Hatred
Mean
Calm
Emotion
Enrage

Chair List
Sit
Legs
Seat
Couch
Desk
Recliner
Sofa
Wood
Cushion
Swivel
Stool
Sitting
Rocking
Bench

Doctor List
Nurse
Sick
Lawyer
Medicine
Health
Hospital
Dentist
Physician
Ill
Patient
Office
Stethoscope
Downy
Kitten
Skin
Tender

Sweet List
Sour
Candy
Sugar
Bitter
Good
Taste
Tooth
Nice
Honey
Soda
Chocolate
Hard
Cake
Tart
Pie

Surgeon
Clinic
Cure

City List
Town
Crowded
Skate
Capital
Streets
Subway
Country
New York
Village
Metropolis
Big
Chicago
Suburb
County
Urban

Needle List
Thread
Pin
Eye
Sewing
Sharp
Point
Prick
Thimble
Haystack
Thorn
Hurt
Injection
Syringe
Cloth
Knitting

Rough List
Smooth
Bumpy
Road
Tough
Sandpaper
Jagged
Ready

Coarse
Uneven
Riders
Rugged
Sand
Boards
Ground
Gravel

Smoke List
Cigarette
Puff
Blaze
Billows
Pollution
Ashes
Cigar
Chimney
Fire
Tobacco
Sting
Pipe
Lungs
Flames
Stain

Trash List
Garbage
Waste
Can
Refuse
Sewage
Bag
Junk
Rubbish
Sweep
Scraps
Pile
Dump
Landfill
Debris
Litter

Window List
Door
Glass
Pane
Shade
Ledge
Sill
House
Open
Curtain
Frame
View
Breeze
Sash
Screen
Shutter

Smell List
Nose
Breathe
Sniff
Aroma
Hear
See
Nostril
Whiff
Scent
Reek
Stench
Fragrance
Perfume
Salts
Rose

Soft List
Hard
Light
Pillow
Plush
Loud
Cotton
Fur
Touch
Fluffy
Feather
Furry

Appendix B: Figures of interactions mentioned in text.