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The Interrelationship of Taxonomic Categories

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College students from two universities performed a sorting task with taxonomic categories. Sorting norms for both subject groups and hierarchical relations among the categories were determined and compared.

Human memory is often thought of as a multitude of associatively related units. Accessibility to any unit is supposedly provided by a somewhat well-defined and permanent semantic organization. Several theoretical accounts have emphasized the hierarchical character of this organizational process (Bousfield & Cohen, 1953; Collins & Quillian, 1969; Mandler, 1968). According to these approaches, subordinate units are related through a superordinate, and lower order superordinates are linked through a higher order superordinate.

The purpose of this study was to gather normative data bearing on the hierarchical organization of semantic memory. A procedure described by Miller (1969) was used to determine the hierarchical scheme among units. Obtaining information from students of two college campuses promised to broaden the generality and usefulness of the findings.

Method

Subjects

One-hundred and forty-seven Marshall University (MU) undergraduates and 95 Ohio State University (OSU) undergraduates participated in this study while enrolled in an introductory psychology course.

Materials

The 56 category names used by Battig and Montague (1969) were typed separately on index cards (7.6 × 12.7 cm). The category of "meats" was added to produce a deck of 57 cards. Several such decks were constructed. These categories with the numbers assigned to them by Battig and Montague are shown on the left side of Figure 1.

Procedure

The MU subjects entered a room permitting data collection on up to 15 people at a time. One wall of the room consisted of 4 × 7 ft. (3 × 6 m) dividers. The subjects sat at small tables between the dividers facing the experimenter. This arrangement permitted subjects to work undisturbed and permitted the experimenter to observe all subjects simultaneously. Each subject read the following instructions:

> This experiment concerns how people sort common categories. Before you is a deck of cards. On each card is typed a category. What you are to do is to divide the deck into piles of cards that you believe go together. Make as many piles as you want. Step 1: To become familiar with all of the categories, lay out, one card at a time, the entire deck before you. Read to yourself each category as you place it on the table. Step 2: Sort the categories into as many piles as you want. Each pile should be comprised of categories that you believe belong together. Work as quickly and carefully as you can. You will have approximately 30 minutes to complete your piles.

Each subject was also told that a pile could consist of a single card. The intention was to avoid any preconception that every card had to be placed with some other card. The experimenter monitored subjects' activities to ensure that Step 1 was completed before Step 2. Even though a time limit was specified, subjects were given as much time as they needed to complete the task.

The numbers assigned to the categories by Battig and Montague (1969) were pencilled on the back of the cards. When the subject had finished sorting, the numbers comprising each pile were recorded. The deck was thoroughly shuffled and left on the table with a copy of the instructions for the next subject.

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The OSU subjects followed a similar procedure, except that only one subject was tested at a time.

Results

All subjects completed the task. The time taken to do the sorting ranged from 20 to 45 min. The subjects tended to spend the last 5 to 10 min examining their piles, often re-sorting some cards into other piles or forming new piles. Several cards typically remained in isolation from others.

The data obtained from each subject were tallied into a matrix. The 57 category names formed the rows and columns; the cells represented the number of times a given category was sorted with any other category. For each subject, a given category could occur in one pile only. Whenever two categories formed a pile, a tally mark was placed in the two cells of the matrix indexed by those two categories. If a pile consisted of more than two categories, a tally mark was placed in all possible combinations indexed by those categories. Once the data from all subjects were entered, the tallies within each cell were summed. One frequency matrix was constructed for MU subjects and one for OSU subjects. The frequencies were divided by their respective total N to produce percentages for each subject sample. Finally, the frequencies of identically indexed cells of the two matrices were summed and divided by the grand total N to obtain a composite percentage matrix.

A listing of associated pairs according to percentage deciles is presented in Table 1, which also includes pairs that had a zero sort in both populations. In the instance of the 10% category, pairs were included only if the two populations did not differ by more than 3 percentage points; thus the 10% pairing probably represents weak but real relationships in the two college populations. A disparity of 7% was permitted for the 20% group, and 8% for pairs above that level.

The Spearman rank-order correlation between the sorts of MU and OSU subjects was .81 ($p < .001$). When only those frequencies tallying more than one third of the subjects were used, rho jumped to .96 ($p < .001$).

Insofar as the distribution of the percentage values is concerned, the most and least frequent values were 0% and 60%, respectively. Of the values, 96% fell within the bottom third of the scale, with only 4% spreading themselves above this cut-off point. These later figures designated the highest degrees of associative overlap among this set of categories.

Miller (1969) has described in detail an iterative procedure termed the diameter method (Johnson, 1967) for producing a "more reliable picture" of hierarchical relations among the stimuli. Briefly, the procedure involves locating the highest value in the matrix. Identity is assumed between the two categories indexing this value, if they relate equally to all other categories. Equality is defined within the range N minus the highest value. When this criterion is met, the categories are clustered and the matrix shrinks by one row and column. The procedure is repeated many times to a criterion set by the user. Whenever the highest value is between a single category and a cluster, or two clusters, the most distant or lowest value among these category combinations determines the point of convergence. The resultant hierarchy tends to reflect conservative estimates of subordinates and superordinates.

A hierarchical scheme was determined for each subject group using the diameter method. The highest value in the matrix was located. The two categories were clustered since both were sorted with all others to approximately the same degree. For example, Categories 21 and 55 were placed in the same pile by 96% of the MU subjects. Category 18 was sorted with Category 55, 16% of the time and also with Category 21, 16% of the time. The relative percentages of Categories 21 and 55 were the same for all other categories as well. The two categories formed a subordinate level of the hierarchy. From this point on in the analysis, Categories 21 and 55 assumed identity and the matrix

TABLE 1

PERCENTAGE OF RELATIONSHIP AMONG CATEGORIES

%	Category relationships
90–99	16–43; 21–54; 21–55; 37–45; 37–53; 45–53; 46–47; 55–93
80–89	2–4; 8–37; 8–45; 20–38; 37–52; 45–52; 48–50; 52–53
70–79	8–52; 9–31; 16–57; 19–32; 31–44; 34–36; 36–42; 39–51; 43–57
60–69	9–44; 18–27; 25–57; 28–30
50–59	1–5; 1–28; 5–33; 6–13; 7–18; 7–27; 11–23; 12–19; 12–32; 16–25; 17–22; 24–27; 25–43; 43–59; 28–33; 33–40; 34–42
40–49	1–33; 3–46; 3–47; 5–28; 7–24; 15–49; 20–25; 25–38; 26–39; 30–33; 30–40
30–39	1–30; 5–26; 5–30; 5–40; 12–24; 12–56; 14–23; 14–32; 16–20; 16–38; 19–56; 20–57; 26–33; 26–51; 28–40; 29–41; 29–42; 32–56; 38–43; 38–57
20–29	1–26; 1–35; 1–40; 6–36; 6–42; 11–14; 11–17; 11–25; 14–19; 16–48; 16–50; 17–23; 23–41; 26–28; 28–48; 28–50; 34–41; 37–48; 37–50; 40–49; 43–48; 43–50; 45–48; 48–52; 50–52; 50–53; 54–56; 55–56
10–19	1–48; 2–30; 2–33; 2–40; 3–24; 4–33; 4–40; 5–17; 5–23; 5–48; 5–50; 6–29; 6–34; 7–46; 7–47; 9–10; 9–35; 10–31; 11–16; 11–34; 11–38; 11–43; 11–57; 12–14; 12–54; 12–55; 13–15; 13–47; 15–30; 16–52; 17–41; 18–21; 18–54; 18–55; 19–54; 19–55; 22–49; 23–32; 27–56; 29–34; 30–48; 30–50; 32–54; 41–42; 43–52; 44–51
0	1–7; 1–18; 1–36; 1–38; 2–16; 2–57; 4–20; 4–43; 4–57; 6–8; 6–16; 6–37; 6–43; 6–45; 6–48; 6–50; 6–52; 6–53; 7–8; 7–37; 7–45; 7–52; 7–53; 8–9; 8–12; 8–18; 8–27; 8–32; 9–16; 9–37; 9–52; 11–24; 11–42; 12–15; 12–16; 12–20; 12–33; 12–37; 12–38; 12–43; 12–45; 12–52; 12–53; 12–57; 13–16; 13–43; 14–16; 14–28; 14–30; 16–18; 16–39; 16–44; 16–51; 17–28; 17–30; 18–33; 18–37; 18–43; 18–52; 20–55; 20–56; 21–25; 21–33; 21–38; 22–25; 24–33; 24–43; 24–57; 25–54; 25–55; 27–37; 27–43; 27–52; 27–53; 27–57; 28–31; 28–38; 28–41; 28–44; 30–31; 31–37; 31–43; 31–50; 31–52; 31–53; 32–37; 32–38; 32–43; 32–52; 32–53; 32–57; 33–54; 33–55; 34–37; 34–52; 35–43; 35–53; 36–43; 36–52; 37–39; 37–44; 37–51; 38–54; 38–55; 39–43; 39–52; 39–53; 40–44; 40–51; 43–46; 43–47; 44–48; 44–52; 44–53; 45–56; 47–57; 50–51; 51–53

was reduced by one row and column. The steps outlined above were repeated. Eventually, one category was linked to a cluster. When this occurred, each member of the cluster was sorted to the same degree with the category. Furthermore, the category and every member of the cluster was sorted to the same degree with every category outside of the cluster. With these criteria met, the category was grouped with the cluster to form a lower order superordinate of the hierarchy. Some clusters related to others. In such cases, each member of the cluster was sorted equally with every other member of the other cluster. The members of both clusters also showed an equal relationship to all categories outside both clusters. This type of comparison revealed higher order superordinates of the hierarchy.

Even though the values of the nodes varied, both subject groups produced almost the same hierarchical scheme. This was not surprising considering their sorting performance. Quantitative differences increased as the degree of associative overlap decreased. The largest discrepancy between nodes was 10%. Despite the disparity, 90% of the nodes had the same relative position in both hierarchies. The structureal difference involved four cases. In three cases, two categories were juxtapositioned with a cluster at degrees of associative overlap below .5. The fourth case concerned a 2% difference between three categories relating .93 in associative overlap. The high similarity between the hierarchies prompted the construction of a composite hierarchy based on the combined percentages. This final analysis produced the hierarchical scheme shown in Figure 1. This hierarchy was taken to be the most representative picture of taxonomic organization.

The results of' this analysis, presented in Figure 1, should be interpreted in the following fashion. The category under consideration is identified on the left and next

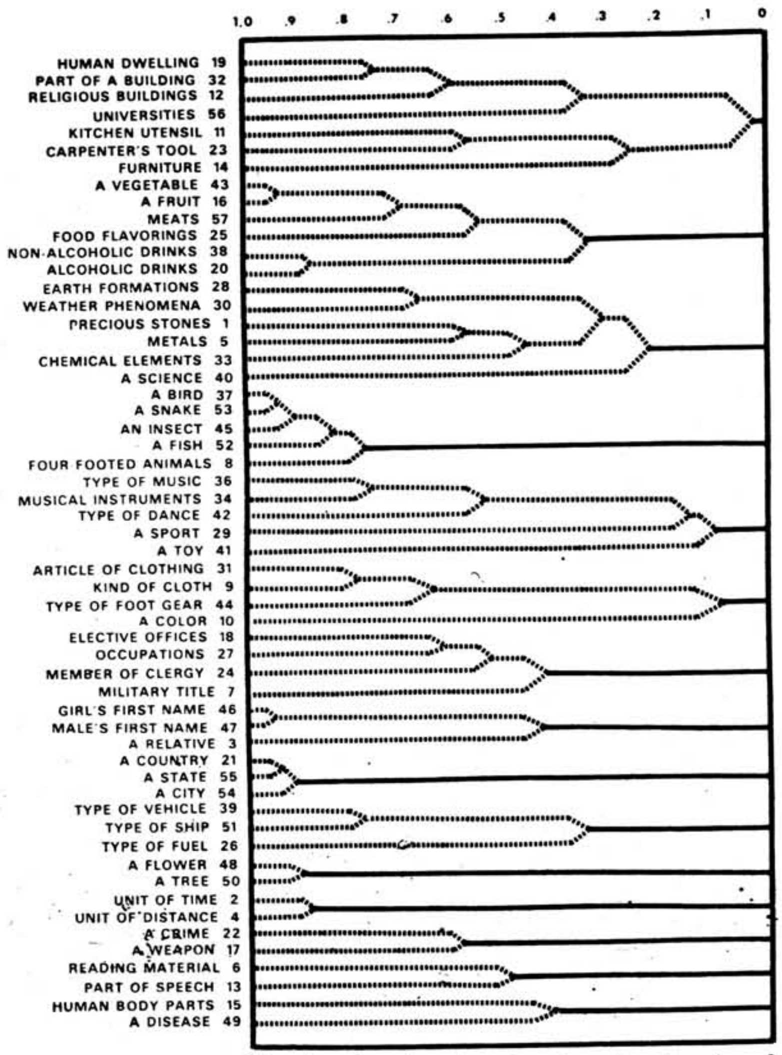

FIGURE 1. Schematic representation of degree of category relationships. (The numbers in the left-hand column identify the categories and the values across the columns refer to the sorting percentage.)

to it is its numerical identification in the Battig and Montague norms.[1] The intersection of the dashed lines represents the degree of association between the categories in question. The value of the association can be determined from the percentages on the top or bottom of the figure. Each cluster is indicated by the occurrence of the solid line to the right, and this implies that the categories in that cluster have essentially a zero relationship to other clusters. For example, at the bottom of the figure, Category 15 (human body parts) and Category 49 (a disease) are sorted together at a value of about 43% and are not sorted with other categories. Higher up on the figure, Category 2 (a unit of time) has about an 88% sort with Category 4 (a unit of distance) but neither of these tend to sort with other categories. The figure may be used as a means of seeing categories which tend to cluster in varying degrees as well as categories which are essentially unrelated. Precise values for selected degrees of relationship are given in Table 1.

Discussion

A high agreement was found in the sorting of these two independent populations for this particular set of categories. The Battig and Montague set of categories was chosen arbitrarily because of the considerable usefulness of the set in modern psychological research. Despite the arbitrary selection, the two populations agree very closely on how the categories should be associated given the particular rules of the game. The basic rules were to sort into as many or few categories as the subject wished. Possibly a different set of hierarchies would have been formed if a restriction had been placed upon the number of superordinate categories to be employed. One word game, for example, starts out with only three categories—animal, vegetable, or mineral—and usually the specific noun can be placed in one of these three categories. Additional categories besides the particular 57 used in this experiment could be added using our same ground rules, and their addition might or might not change the hierarchical structure. The fact, however, that these two populations behaved so similarly with respect to our arbitrarily selected categories gives some evidence that the research is touching upon a relatively stable taxonomic structure of semantic memory under a fairly permissive type of ground rules.

Regardless of the theoretical and empirical problems involved in probing the structure of semantic memory, the data of this research, combined with the specific words of the Battig and Montague norms, may be useful in controlling relationships to be used for work in such various fields as semantic memory, release from proactive inhibition, and intra- or interlist interference studies in the more classical areas of verbal learning and memory, as well as other fields.

[1] One category (35) from the Battig and Montague norms, "a kind of money," is omitted from this figure because it was so weakly related to any other category. Its highest sort value was 20% with "a precious stone," but it was poorly related to the other categories in that cluster.

REFERENCES

Battig, W. F., & Montague, W. E. Category norms for verbal items in 56 categories: A replication and extension of the Connecticut category norms. *Journal of Experimental Psychology Monograph*, 1969, *80*(3, Pt. 2).

Bousfield, W. A., & Cohen, B. H. The effects of reinforcement on the occurrence of clustering in the recall of randomly arranged associates. *Journal of Psychology*, 1953, *36*, 67–81.

Collins, A. M., & Quillian, M. R. Retrieval time from semantic memory. *Journal of Verbal Learning and Verbal Behavior*, 1969, *8*, 240–247.

Johnson, S. C. Hierarchical clustering schemes. *Psychometrica*, 1967, *32*, 241–254.

Mandler, G. Association and organization: Facts, fancies, and theories. In T. R. Dixon & D. L. Horton (Eds.), *Verbal behavior and general behavior theory*. Englewood Cliffs, N.J.: Prentice-Hall, 1968.

Miller, G. A. A psychological method to investigate verbal concepts. *Journal of Mathematical Psychology*, 1969, *6*, 169–191.

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