CATECHOLLISION: A game to teach catecholamine synthesis for IBM PCs and compatibles

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CATECHOLLISION is an arcade-style computer game that teaches catecholamine synthesis. Tyrosine and the enzymes involved in the synthesis fall from the top of the screen. The player must combine them to produce DOPA and the catecholamines. An accumulation of unused chemicals ends the game. The game includes features such as music and sound effects, several levels of difficulty, a hint option for beginning students, and saved high scores.

The catecholamines are neurotransmitters that play important roles in many aspects of behavior. Dopamine, for example, is thought to be involved in pleasure (e.g., Fouriez & Wise, 1976), motor control (e.g., Ungerstedt, 1974), and schizophrenia (e.g., Creese, Burt, & Snyder, 1976). Norepinephrine has been implicated in mood and depression (e.g., McNeal & Cimbalic, 1986) and in learning (e.g., Gray, Freeman, & Skinner, 1986). Epinephrine's primary behavioral involvement occurs through its peripheral role in sympathetic arousal, but it also occurs centrally (Hökfelt, Fuxe, Goldstein, & Johansson, 1973). These neurotransmitters share a common synthetic pathway and similarities in chemical structure: all contain a catechol ring and an amine group. A familiarity with these neurotransmitters and their synthesis is of value to the student of physiological psychology and to the clinician who sees patients who are on medications that affect the catecholamines.

Computer games can facilitate learning by increasing the meaningfulness of the material being learned. For example, BRAINSCAPE (Wilson & Ostergren, 1985, 1986) allows the student to explore the brain in an adventure game format, learning neuroanatomy in the process. CATECHOLLISION is an arcade game in which the student manipulates the precursors and enzymes involved in the synthesis of the catecholamines. In the process, the student learns the synthesis readily, motivated by the desire to score points and achieve a high score. The familiarity with the catecholamines gained in this fashion can then be applied to more academic or clinical purposes.

Playing the game. The synthesis of the catecholamines occurs via the following steps:

tyrosine	
	← tyrosine hydroxylase
DOPA	
	← DOPA decarboxylase
dopamine	
	← dopamine beta-hydroxylase
norepinephrine	
	← PNMT
epinephrine,	

with precursors shown on the left and enzymes on the right. In CATECHOLLISION, tyrosine and the enzymes fall from the top of the screen, forming piles at the bottom. The player can move the falling substance to the left and right, and cause it to drop rapidly. The player's goals are twofold: to keep the piles as low as possible, and to create catecholamines by combining precursor and enzyme. If tyrosine hydroxylase is dropped onto tyrosine, for example, both disappear and are replaced by DOPA. Points are awarded whenever such a combination occurs. The game ends when one of the piles exceeds an upper limit.

Game features. Four levels of difficulty exist within CATECHOLLISION. In each, the player must manufacture 30 molecules of a specific catecholamine before moving to the next level. Within each level, only those enzymes necessary to the production of the target catecholamine fall, and the target catecholamine is removed upon production. In Level 1, for example, dopamine is the target, and tyrosine, tyrosine hydroxylase, and DOPA decarboxylase fall. The player must synthesize both DOPA and dopamine. Once 30 molecules of dopamine have been made, Level 2 begins. In this level, dopamine beta-hydroxylase is provided along with the substances that have been dropping, and the player must synthesize norepinephrine. In Level 3, PNMT also falls, and epinephrine must be produced. Level 4 differs, in that in addition to synthesizing catecholamines, the player uses monoamine oxidase, an enzyme that catabolizes the catecholamines, to remove them from the screen.

Within Levels 1, 2, and 3, the speed at which the substances fall increases throughout the level, increasing the challenge to the player. The speed resets to its baseline value when the level changes. In Level 4, the speed increases initially and then stabilizes. The speed increase can be disabled if the player finds it too challenging, but fewer points are awarded in this case.

Within each game, the computer keeps a cumulative record of the number of molecules of each substance that it has provided to the player, and the number of molecules of DOPA, dopamine, norepinephrine, and epinephrine that the player has synthesized. Substances fall at random, with the constraint that no more than five molecules of the same substance will fall consecutively.

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The program will, if desired, suggest a target on which to drop each falling substance. This is useful for the novice, but it greatly reduces the number of points awarded.

The program has a musical score and sound effects. These can be inactivated if the user finds them distracting, or if the program will be used in a classroom setting where they might distract others. The program saves to disk the setting (on/off) of sound, as well as the speed setting (incremental/constant) and the suggested targets setting (on/off), so that these options need be set only once if a change is not desired.

Screens accessible through a menu provide information about the catecholamines, about playing the game, and about distributing copies of the program to others.

Hardware requirements. CATECHOLLISION is written in Turbo Pascal 5.5 (Borland International, 1989) for the IBM PC, XT, AT, and compatibles. It requires a graphics card (CGA, EGA, VGA, or Hercules) and looks best on a color EGA or VGA system. The CGA version is monochromatic, as is the Hercules version, by definition. The EGA and VGA versions can be run on monochrome monitors if necessary.

Different computers run at different speeds, depending on the speed of the processor chip and the speed of the graphics card, among other things. CATECHOLLISION includes a timing routine that adjusts its speed to match that of the computer, with some limitations: the program cannot compensate for very slow machines. Users with 8088-based computers might find the program too slow.

Availability. CATECHOLLISION is being distributed as shareware. The disk includes versions of the program for CGA, EGA, VGA, and Hercules systems, a User's Guide that can be printed, and a screen of information explaining how to use the program and print the User's

Guide. To receive a free copy, send a 5.25- or 3.5-in. disk and a self-addressed, *postage-paid* disk mailer to the authors. A registration fee of \$20 is requested from those who use and enjoy the program. For \$25 the authors will provide the disk and mailer, and list the user among those registered. Registration will ensure the user of notification of any upgrades or related programs.

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