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Perception and Memory Experiments Using Drug Names

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Background and Significance

Drug names that look and sound alike are a leading cause of medication errors (e.g., diazepam and diltiazem, hydroxyzine and hydralazine, *Paxil* and *Taxol*, fomepizole and omeprazole, *Foradil* and *Toradol*).[1-5] The U.S. Pharmacopeia published a comprehensive review of name confusion errors from two large databases of spontaneous error reports (MEDMARX and IMSP/USP Medication Error Reporting Program) covering the years 2003-2006.[6] They identified 26,604 look-alike/sound-alike errors involving 3,170 confusing pairs of drug names, 1.4% of which caused patient harm. Observational studies of dispensing in outpatient pharmacies suggest that the rate of wrong drug errors—the type most likely to be the result of name confusion—is roughly 0.13%.[7] With 3.9 billion prescriptions dispensed in 2009,[8] that translates to 5 million wrong drug errors per year in the U.S. If 6.5% were clinically significant,[7] that would mean potential harm to roughly 325,000 people annually. Wrong drug errors are the most common source of malpractice claims against pharmacists.[9] Despite advances in technology, policy and practice, and more than a decade of focused effort, preventing drugs with similar names from being confused by clinicians and patients remains an elusive goal.

Preventing harm from drug name confusions requires both pre-approval and post-approval strategies. Pre-approval strategies ensure that confusing *new* drug names do not enter the marketplace. Pre-approval tests include database searches for existing similar names or products,[10] soliciting expert judgments about confusability,[11] doing traditional psycholinguistic tests on memory and perception,[3,12,13] and observing error rates during simulated ordering, dispensing, and administration tasks.[14,15] The FDA recently released a white paper proposing an integrated approach to pre-approval screening of drug names, inviting manufacturers to participate in a pilot project to evaluate the proposed approach.[16] Unfortunately, response to the program has been poor, with very few companies entering into the pilot.

In summary, there are important knowledge gaps and opportunities for improvement when it comes to preventing harm from drug name confusion. In the pre-approval context, there is a need for a clear demonstration of an integrated approach to pre-approval testing of proposed new drug names, with step-by-step guidance and examples that illustrate procedures for conducting experiments, conducting computer database searches, and for organizing, analyzing and interpreting the resulting data. To address these safety gaps we will develop and test a standard protocol for pre-approval testing of names.

Study Hypothesis and Specific Aims

The purpose of this overall project was to develop, demonstrate and disseminate a standard protocol for pre-approval testing of drug names, including a standard battery of psycholinguistic tests and data analytic methods, all with comparison to control names. The achievement of this aim will provide both regulators and pharmaceutical manufacturers with a scientifically validated, step-by-step method for testing new drug names for confusability.

The purpose of the present study was to refine and demonstrate our analytic methods by conducting a series of visual perception, auditory perception, and short term memory experiments using drug names as stimuli.

Methods

EXPERIMENT 1: PROGRESSIVE DEMASKING

Methods

Design and Task

We used a cross-sectional, observational design to study clinicians' ability to correctly identify drug names presented visually on a laptop computer screen. The task that subjects engaged in is known as progressive demasking because it involves identifying a visual stimulus as it is progressively revealed from behind an obscuring mask of #'s.

Participants

Participants were recruited from among the staff at a large children's hospital in Ottawa, Ontario, Canada. The project was approved by the ethics review board of the hospital. Participants were paid an honorarium in exchange for their participation, and the hospital was paid a fee in exchange for allowing the experimenters to set up an on-site data collection facility in a hospital meeting room. A total of n=66 people completed Experiment 1 over a two-day period, 30 on day one and 36 on day two. After examining preliminary results at the end of day 1, we identified two problems. First, many participants were ignoring the instructions and waiting until the stimulus was totally unmasked before responding, and second, an error in the program truncated the captured responses at 20 characters, making most of the data for the OTC names unusable. As a result, we fixed the program and modified the instructions slightly for day 2. Only results from day 2 participants are reported below.

Table 1 shows demographic characteristics of the N=36 participants in Experiment 1. Participants were primarily female (n=31, 86%), nurses (n=16, 44%) and pharmacists (n=11, 30.6%) along with a few physicians, pharmacy technicians and pharmacy students. Average age was 38.5 (SD=11.1), with 13.3 (SD=11.3) years of experience.

Stimulus Materials

This experiment used the names of 105 drugs, biologics and natural products taken from the Canadian Drug Product Database (DPD) and the Canadian Licensed Natural Health Product Database (LNHPD) (see Table 2). We began by selecting five categories of health product names to be included as test names. These categories were: an injectable prescription drug product, an oral solid prescription drug product, a biological product, an OTC product, and a natural heath product. Because one of the objectives was to determine how the new screening procedure would perform on confusing names, we decided that three of the names (the injectable, the biologic, and the NHP name) should be selected from among names that had previously appeared in published reports of drug name confusion errors. These were identified using a combined list of names involved in published lists of look-alike/sound-alike errors. This list had previously been constructed as part of a separate project on drug name confusion. Other than the three "error" names, all other test names and control names were selected as stimuli only if they did *not* appear in the database of published confusing names.

Test names. Selecting the names was a multi-step process. Within each category, first the test names were chosen at random. Membership in a given category of drugs (e.g., Rx, OTC, biologic, oral, injectable, natural health product) was determined by codes in the DPD or by inclusion in the LNHPD. For example, to select an injectable name that had previously appeared in a published list of LASA errors, we took all injectable drugs from the DPD and identified the subset of those that were also on the list of published LASA errors. We then selected randomly from among the LASA injectable names, finally selecting *Taxotere*, which had previously been

confused with *Taxol.* We followed a similar procedure for the biologics, leading to the selection of *Neulasta* (which had been confused with *Neumega*), and for NHP names, selecting *Aquasol E* (previously confused with *Aquasol A*). We also insisted that test names appear in the bottom two-thirds of products ranked by Canadian sales volume, according to data provided by IMS. By selecting the names from the lower two-thirds of the sales volume list, we insured that the test names had relatively low familiarity and would therefore be more like the unfamiliar new names that are typically presented to federal regulators for approval.

Control names. For each test name, we selected 20 additional control names from the same category, matched as closely as possible on the number of letters in the test name. For Rx, OTC and biologic products, control names were defined as any name that met two criteria: (1) it had been on the market for at least 5 years (prior to January 2010), according to the earliest "Marketed (notified)" date in the DPD; (2) it did not appear in our master list of previously published LASA (look-alike/sound-alike) error reports. By insisting that the name be on the market for at least 5 years, we reduced the chance that a name would not appear on our LASA error list simply because of its recent appearance on the market. We realized that this was not a perfect definition of control names. Because many LASA errors go unreported it is possible that some of our control names may have been involved in unreported errors. Nevertheless, this approach likely succeeded in eliminating most known confusing names from our list of controls.

Practice names. The first 10 trials of the experiment were used to familiarize participants with the task. The practice names were chosen at random (*Iressa, Mucaine, Suprane, Eligard, Glycemin, Septopal, Pregvit, Minirin, Tazorac, Antherpos*). Reponses to these names were not scored.

Final set. Because the OTC part of the experiment was dropped on day 2 of data collection, each participant responded to a total of 94 names: 10 practice names and 84 experimental trials. The 84 experimental names were comprised of 4 test names, each matched with 20 different controls (see columns 1, 2, 4 and 5 from Table 2).

Procedure

Participants, recruited in advance via email and posted announcements, arrived at the testing room in groups of four. Each filled out a brief demographic questionnaire and read a simple consent form before entering a room containing 4 laptop computers. Each person was seated in front of a laptop, and the experimenter read a set of instructions describing the task:

> **Progressive Demasking**
> *In this experiment, you will be visually presented with a drug name which is obscured by a row of #####'s. At first, the name will be presented very briefly, followed by the ####'s. Gradually the name will appear for longer and the ####'s will appear only briefly. Your task is to press the <SPACE> bar AS SOON AS YOU RECOGNIZE the drug name. After you hit the <SPACE> bar, type in the name of the drug, then hit <ENTER> to begin the next trial.*
>
> *Do not wait until the drug name is unmasked and fully visible on the screen. It is critical that you hit the space bar and respond before the name is fully unmasked.*

The task begins with 10 practice trials, followed by 105 experimental trials. Please respond to each trial as QUICKLY and as accurately as you can. If you have any questions, there is a pause built into each experiment. Wait for the pause, then raise your hand and we will answer your questions.

When you are done, raise your hand and one of us will guide you through the next phase of the exercise.

Thank you for participating.

We used the PDM software package (freely available at www.up.univ-mrs.fr/wlpc/pdm) to conduct the experiments. The screen size was set to 1024 x 768 pixels, color depth to 32 bits. Each trial began with a 500 millisecond fixation point. The experiment was conducted in full-screen mode with a refresh rate of 60Hz. There were 7 refresh cycles for every mask-target pair. Table 3 displays the duration of exposure for targets and masks on each of the 7 cycles in a given trial. Since each screen refresh lasts 1/60th of a second, each 7-refresh cycle lasted 116.8 milliseconds (7 * 1/60th = 116.7ms). The total duration of each trial was 816.67 ms, but after 600ms (583.3 + 16.17) the target was on the screen constantly with no mask (see Table 3)

Table 3. Target and mask exposure durations for each trial consisting of 7 screen refresh cycles (60 Hz).

Cycle	Mask Refreshes	Target Refreshes	Exposure Duration			
			Mask	Target	Total	Cumulative
1	6	1	100.00	16.67	116.67	116.67
2	5	2	83.33	33.33	116.67	233.33
3	4	3	66.67	50.00	116.67	350.00
4	3	4	50.00	66.67	116.67	466.67
5	2	5	33.33	83.33	116.67	583.33
6	1	6	16.67	100.00	116.67	700.00
7	0	7	0.00	116.67	116.67	816.67

There was a 1.5 second interval between trials, and a user-controlled pause after 10 practice trials and after the 50th experimental trial. Stimuli appeared in a plain 12-point Arial font. The masking characters (#) also appeared in a plain 12-point Arial font. The 84 stimulus names appeared in a different random order for each participant.

Finally, each participant completed a brief questionnaire rating the familiarity of each name in the experiment on a 7-point semantic differential scale, ranging from extremely unfamiliar to extremely familiar.

Scoring. Verbatim typed responses were extracted from the program output and scored as correct if they exactly matched the stimulus name for a given trial. Any deviation from exact matching, even minor spelling errors, was scored as incorrect.

Content analysis of incorrect responses. One advantage of this experimental task is that participants must type in a free text response on every trial. When the answer is correct, these responses are of little interest, but when the answer is incorrect, the free text responses can be very informative, illustrating the specific patterns of misperception that subjects experience, and providing information about what types of confusions people might make, not just the number of

those confusions. For all incorrect responses, free text answers will be sorted by frequency and content analyzed in relation to the respective target names.

EXPERIMENT 2: VISUAL PERCEPTUAL IDENTIFICATION ("PICK-FROM-PAIR")

Methods

Design and Task

We used a cross-sectional, observational design to study participants' ability to correctly select a target drug name from a pair of similar drug names after a brief visual presentation of the target on a computer monitor. We refer to this task as 'pick-from-pair.'

Participants

Participants were recruited from among the staff at a large children's hospital in Ottawa, Ontario, Canada. The project was approved by the ethics review board of the hospital. Participants were paid an honorarium in exchange for their participation, and the hospital was paid a fee in exchange for allowing the experimenters to set up an on-site data collection facility in a hospital meeting room. A total of n=54 participants completed Experiment 2 over a two-day period. Table 4 shows demographic characteristics of the N=54 participants in Experiment 2. Participants were primarily female (n=46, 85%), nurses (n=21, 38.9%) and pharmacists (n=17, 31.5%) along with a few physicians, pharmacy technicians and pharmacy students. Average age was 39.2 (s.d.=10.4), with 13.2 (s.d.=11.5) years of experience.

Stimulus Materials

Target names. The stimulus names were the same as those described in Experiment 1, except OTC names were included in this experiment. The final set included 105 names (see Table 2).

Nearest neighbor names. Each target name was paired with its nearest neighbor name. For a given target name, the nearest neighbor was defined as the name with the highest similarity to the target name (other than the target itself). To identify nearest neighbors, we computed the similarity between each target and every name in the combined DPD/LNHP database from Health Canada, excluding all but human drugs from the DPD. The name with the highest similarity score was paired with the target. To compute this similarity score, we used the Editex similarity measure. Table 5 gives the target names, nearest neighbors and Editex distance for all the non-OTC names in Experiment 2. Table 6 gives the targets, neighbors and distances for all the OTC names in Experiment 2.

Procedure

We recruited and scheduled participants in advance via email and posted announcements. Participants arrived at the testing room in groups of four, each filling out a brief demographic questionnaire and reading a simple consent form before entering a room containing 4 laptop computers. Each person was seated in front of a laptop, and the experimenter read a set of instructions describing the task:

> *Each trial in this experiment has four parts. First you will see a plus sign (+) to direct your attention to the center of the screen.*

Next you will see a TARGET drug name. Then you will see a series of x's blocking out the target name, followed by a pair of drug names, one of which is the target name.

One name will be on the left side of your screen, and one on the right side.

Your task is to pick which of the two names is the target name. Press the far left button to pick the name on the LEFT or the far right button to select the name on the RIGHT. Make your selections AS QUICKLY AS YOU CAN.

Press the center button to start the 10 practice trials.

We used SuperLab stimulus presentation software (version 4.07b) to conduct the experiments. The experiment began with 10 practice trials and was followed by 84 non-OTC trials and then 21 OTC trials. Each trial began with a fixation point (+) which remained on the screen for 2 seconds in 14 point Tahoma font at the center of the screen. Then the target name appeared on the screen at the same location as the fixation point for 40 milliseconds (ms). The target name was then replaced by a string of 16 Xs in 12 point Tahoma font in the center of the screen. The row of Xs remained on the screen for 1 second. Then a pair of names appeared at the center of the screen. One of the names was the target and one was a name similar to the target (i.e., its nearest neighbor). Whether the target appeared on the left or the right side of the screen was determined at random. Participants indicated which name they thought was the target name by pressing the left or right button on a button box (Cedrus model RB-730, see Figure 1) connected to the laptop via a USB cable.

Scoring. The correct location of the target name (either left or right) was pre-programmed into SuperLab for each name pair. SuperLab automatically scored each participant's response as correct or incorrect. SuperLab also recorded a reaction time, i.e., the number of milliseconds between the appearance of the target/neighbor pair and a button press of 'left' or 'right'. Raw data were exported from SuperLab and imported in to Stata 11 for analysis.

EXPERIMENT 3: AUDITORY PERCEPTUAL IDENTIFICATION (IN NOISE)

Methods

Design and Task

We used a cross-sectional, observational design to study clinicians' ability to correctly identify a spoken drug name played back over headphones against a background of multi-speaker babble. This task is known as auditory perceptual identification.

Participants

We recruited participants from among the staff at a large children's hospital in Ottawa, Ontario. The project was approved by the ethics review board of the hospital. Participants were paid an honorarium in exchange for their participation, and the hospital was paid a fee in exchange for allowing the experimenters to set up an on-site data collection facility in a hospital meeting room. A total of n=42 participants completed Experiment 3 over a two-day period. Table 7 shows demographic characteristics of the participants in Experiment 3. Participants were primarily female (n=37, 88%), nurses (n=16,38%) and pharmacists (n=8, 19%) along with physicians, pharmacy technicians and pharmacy students. Average age was 39 (SD=12), with 16 (SD=11) years of experience.

Stimulus Materials

The stimulus materials were a 69-name subset of those used in Experiment 2 (see Tables 2 and 6), except 5 additional names were added (*Altocor, amrinone, Kapidex, Omacor* and *Reminyl*). These additional names had all been removed from the market in the U.S. due to drug name confusion problems. They were included in this experiment to serve as negative controls.

Names were digitally recorded by a male speaker. All names were spoken in a sentence context. The name portion of the sentence was isolated and extracted from the recording. Then each audio file (containing one name) was normalized and the dB of each file was equated to the dB of the quietest file. These last two steps were carried out using the free Praat audio editing software. Then each name file was mixed with background noise (Multispeaker Babble from Auditec of St. Louis) at a fixed signal-to-noise ratio (noise at 65 dB, signal at 73 dB, S/N ratio= +8 dB).

Procedure

We recruited and scheduled participants in advance via email and posted announcements. Participants arrived at the testing room in groups of four. Each filled out a brief demographic questionnaire and read a simple consent form before entering a room containing 4 laptop computers. Each person was seated in front of a laptop, and the experimenter read a set of instructions describing the task:

> *In this experiment your task is to identify spoken drug names that are played back on your headphones against a background of multi-talker babble.*
>
> *Each trial has three parts:*
>
> *1. First you will see 5 asterisks (*****) flash on the screen, indicating that a drug name is about to be played. Then, a spoken drug name will be presented over your headphones.*
>
> *2. Next you type the name you heard into a text box and hit <Enter> when you are done.*
>
> *3. Finally, a list of 6 drug names will appear on the screen. Use your mouse to click on the name that you heard.*
>
> *As soon as you have responded, a new trial will begin. All of the drug names will be played against a background of multi-talker babble.*
>
> *You will have 5 practice trials to get comfortable with the task.*
>
> *When you are ready to begin, press the <Space> key.*

Scoring. The correct location of the target name in the pick list was pre-programmed into SuperLab for each target name, and SuperLab automatically scored each participant's response as correct or incorrect. SuperLab also recorded a reaction time, i.e., the number of milliseconds between the appearance of the pick list and the selection of a name from the list. Raw data were exported from SuperLab and imported in to Stata 11 for analysis.

EXPERIMENT 4: RECOGNITION MEMORY

Methods

Design and Task

We used a cross-sectional, observational design to study clinicians' ability to correctly remember a drug name after it is briefly displayed on a computer screen. We refer to this task as recognition memory.

Participants

Participants were the same as those in Experiment 3.

Stimulus Materials

The stimulus materials were the a 69-name subset of those used in Experiment 2 (see Tables 2 and 6), except 5 additional names were added (*Altocor, amrinone, Kapidex, Omacor* and *Reminyl*). These additional names had all been removed from the market in the US due to drug name confusion problems. They were included in this experiment to serve as negative controls.

Procedure

Participants had been recruited and scheduled in advance via email and posted announcements. Participants arrived at the testing room in groups of four, each filling out a brief demographic questionnaire and reading a simple consent form before entering a room containing 4 laptop computers. Each person was seated in front of a laptop, and the experimenter read a set of instructions describing the task:

> *In this experiment your task is to remember a drug name that is briefly presented to you on the screen.*
>
> *The experiment has 3 steps:*
>
> *1. See the target name.*
>
> *2. Solve a brief mental arithmetic problem, and input the answer with the keyboard.*
>
> *3. Pick the target name from a list of names by clicking on it with your mouse.*
>
> *Complete each task as QUICKLY and as ACCURATELY as you can.*
>
> *You will have 5 practice trials to get comfortable with the task.*
>
> *When you are ready to begin, press the <Space> key.*

Scoring. The correct location of the target name in the pick list was pre-programmed into SuperLab for each target name, and SuperLab automatically scored each participant's response as correct or incorrect. SuperLab also recorded a reaction time, i.e., the number of milliseconds between the appearance of the pick list and the selection of a name from the list. Raw data were exported from SuperLab and imported in to Stata 11 for analysis.

Table 1. Demographics of Participants (n=36) in Experiment 1: Progressive Demasking

Characteristic	Mean (SD)	Range
Age (n=36)	38.5 (11.1)	22-56
Experience (n=35)	13.3 (11.3)	0-35
Gender	**N (%)**	
Male	5 (13.9)	
Female	31 (86.1)	
Language		
English	27 (75.0)	
French	5 (13.9)	
Other	3 (8.3)	
Missing	1 (2.7)	
Licensed		
Yes	29 (80.6)	
No	7 (19.4)	
Profession		
MD	2 (5.6)	
RN	16 (44.4)	
RPh	11 (30.6)	
Pharmacy Tech.	4 (11.1)	
Pharmacy Student	3 (8.3)	
Degree		
MD	1 (2.8)	
RN	14 (38.9)	
RPh	4 (11.1)	
PharmD	4 (11.1)	
BS	7 (19.4)	
Other	5 13.9)	
None	1 (2.8)	
Dominant Hand		
Right	34 (94.4)	
Left	2 (5.5)	

Table 2. Stimulus Names for Experiment 1 and 2

Biologics	Natural Health Products	OTC	Rx Oral	Rx Injectable
Neulasta[1,2]	Aquasol E[1,2]	Relievol Allergy Sinus Caplets Extra Strength[1]	Parsitan[1]	Taxotere[1,2]
Act-Hib	Amygdales	Balminil DM + Decongestant + Expectorant	Apo-Sulin	Baciject
Amevive	Arthron 5	Balminil DM + Expectorant Extra Strength	Apo-Verap	Betaject
Betaseron	Artichaut	Children's Coltalin Fruit Flavor Chewable Cold	Cystadane	BSS Plus
Center-Al	Atropinum	Coricidin II Extra Strength Cold And Flu	Dalmacol	Cetrotide
Dukoral	Blueberry	Denti-Care Prophylaxis Paste With Fluoride	Dexasone	Diazemuls
Immucyst	Carthamex	Dristan Long Lasting Nasal Spray Mentholated	Euglucon	Diphenist
Intron A	Cetecal D	Extra Strength Head Cold And Sinus Caplets	Formulex	Epipen Jr
Neisvac-C	Dangguisu	Extra Strength Sinus Medication Daytime Relief	Hydergine	Extraneal
Ovidrel	Eurocal D	Hot Lemon Relief For Symptoms Of Cough And Cold	Lectopam	Fortaplex
Pegasys	Glonoinum	Magnesia's Pellegrino Type Mmmm Effervescent	Lescol XL	Hemabate
Pegetron	Glutamine	Multigenics Intensive Care Formula Without Iron	Mazepine	Kidrolase
Pregnyl	Hepatinum	Muscle And Back Pain Relief Extra Strength	Norventyl	Quelicin
Priorix	Homeoslim	Nasal Decongestant Spray With Moisturizers	Nu-Cimet	Remodulin
Pulmozyme	Melaton-3	Preservative-Free Thera Tears Lubricant Eye Drops	Nu-Pindol	Robaximol
Repronex	Modu Chol	Rheuma Heilkrauter Tee (Rheumatism Herbal Tea)	Parvolex	Rogitine
Stemgen	Osteomate	Ricola Swiss Lemon-Mint Herb Cough Drops	Protylol	Serostim
Typherix	Pain Ease	Scott's Emulsion Of Cod Liver & Capelin Oil	Sensipar	Suprefact
Typhim Vi	Florabile	Sucrets Cough Control Extra Strength Lozenges	Tebrazid	Thyrogen
Varilrix	Ultra Efa	Timed Release Ultra Mega Gold Without Iron	Ulcidine	Valtaxin
Vivotif	Uristatin	Vicks Custom Care Chest Congestion/Cough	Yohimbine	Vascoray

Note: Superscript 1 indicates test names. Superscript 2 indicates names previously involved in published name confusion errors. OTC names were excluded from Experiment 1.

Table 4. Demographics of Participants (N=54) in Experiment 2 ("Pick from Pair")

Characteristic	Mean (SD)	Min
Age (n=52)	39.2 (10.4)	22-56
Experience (n=51)	13.2 (11.5)	0-35
Gender	**N (%)**	
Male	8 (14.5)	
Female	46 (85.2)	
Language		
English	39 (72.2)	
French	8 (14.8)	
Other	5 (9.3)	
Missing	2 (3.7)	
Licensed		
Yes	43 (79.6)	
No	11 (20.4)	
Profession		
MD	5 (9.3)	
RN	21 (38.9)	
RPh	17 (31.5)	
Pharmacy Tech.	8 (14.8)	
Pharmacy Student	3 (5.6)	
Consumer		
Degree		
MD	4 (7.4)	
RN	20 (37.0)	
RPh	6 (11.1)	
PharmD	5 (9.3)	
BS	9 (16.7)	
Other	8 (14.8)	
None	3 (5.6)	
Dominant Hand		
Right	52 (96.3)	
Left	2 (3.7)	

Table 5. Target Names, Nearest Neighbor Names and Editex Distance (Experiment 2)

Target	Neighbor	Editex
act-hib	actos	10
amevive	amatine	8
amygdales	amygdeel	8
apo-sulin	apo-gain	8
apo-verap	apo-peram	5
aquasol e	atasol 8	9
arthron 5	arthron	6
artichaut	artechol	9
atropinum	abrotanum	8
baciject	betaject	7
betaject	baciject	7
betaseron	betaxin	10
blueberry	bilberry	8
bss plus	betullus	9
carthamex	cardamom	9
center-al	control	10
cetecal d	cical	14
cetrotide	choroide	9
cystadane	cetacaine	10
dalmacol	dalmane	8
dangguisu	digest	12
dexasone	depakene	8
diazemuls	diazepam	11
diphenist	dipentum	11
dukoral	doloral	5
epipen jr	epipen	9
euglucon	eupion	11
eurocal d	euro d	9
extraneal	estrogel	9
florabile	florasil	6
formulex	formule a	6
fortaplex	formulex	8
glonoinum	glycerinum	10
glutamine	glutapure	8
hemabate	hemoban	8
hepatinum	hepaton-s	8
homeoslim	homeocap	10
hydergine	hytrin	11
immucyst	imuran	11

intron a	ironol	12
kidrolase	karesse	13
lectopam	lycopus	10
lescol xl	lescol	9
mazepine	mycamine	9
melaton-3	melatonin	6
modu chol	monurol	11
neisvac-c	nevanac	11
neulasta	neuleptil	10
norventyl	nervosyl	10
nu-cimet	nu-nifed	8
nu-pindol	nu-indo	6
osteomate	osteocit	8
ovidrel	oxytrol	9
pain ease	pain aid	9
parsitan	parnate	10
parvolex	pariodex	6
pegasys	pegalax	7
pegetron	protrin	10
pregnyl	pronal	7
priorix	protrin	8
protylol	propofol	8
pulmozyme	pulminum	10
quelicin	quetiapine	11
remodulin	robitussin	12
repronex	reparagen	11
robaximol	robaxin	8
rogitine	reactine	8
sensipar	senior	8
serostim	serofin	8
stemgen	sialgen	8
suprefact	suplevit	9
taxotere	taxol	11
tebrazid	tofranil	11
thyrogen	thyrocsin	7
typherix	thyplex	10
typhim vi	typherix	14
ulcidine	urixin	11
ultra efa	ultra mega	6
uristatin	urixin	11
valtaxin	voltaren	7
varilrix	varizig	8
vascoray	vasotec	10

vivotif	vivotif l	6
yohimbine	yasmin	13

Table 6. Target and Nearest Neighbor Names for OTC Drugs

Target	Neighbor	Editex
balminil dm + decongestant + expectorant	balminil codeine + decongestant + expectorant	16
balminil dm + expectorant extra strength	balminil dm + expectorant	44
children's coltalin fruit flavor chewable cold	children's tylenol cold chewable	61
coricidin ii extra strength cold and flu	coricidin ii cold and flu	42
denti-care prophylaxis paste with fluoride	dr. ken toothpaste with fluoride	54
dristan long lasting nasal spray mentholated	dristan long lasting nasal mist	41
extra strength head cold and sinus caplets	extra strength tylenol allergy sinus caplets	34
extra strength sinus medication daytime relief	extra strength cold medication (daytime rel)	24
hot lemon relief for symptoms of cough and cold	hot lemon relief for symptoms of cough	26
magnesia's pellegrino type mmmm effervescent	magnesia s. pellegrino	62
multigenics intensive care formula without iron	multigenics intensive care formula	34
muscle and back pain relief extra strength	muscle and back pain relief regular strength	14
nasal decongestant spray with moisturizers	no7 soft and sheer tinted moisturizer spf	66
preservative-free thera tears lubricant eye drops	preservative-free cosopt	75
relievol allergy sinus caplets extra strength	relievol sinus caplets extra strength	21
rheuma heilkrauter tee (rheumatism herbal tea)	red maple naturals prenatal formula	77
ricola swiss lemon-mint herb cough drops	ricola swiss herb cough drops	33
scott's emulsion of cod liver & capelin oil	seven seas cod liver oil	69
sucrets cough control extra strength lozenges	sucrets extra strength cherry lozenges	54
timed release ultra mega gold without iron	timed release ultra mega gold	34
vicks custom care chest congestion/cough	vicks custom care nasal congestion/cough	13

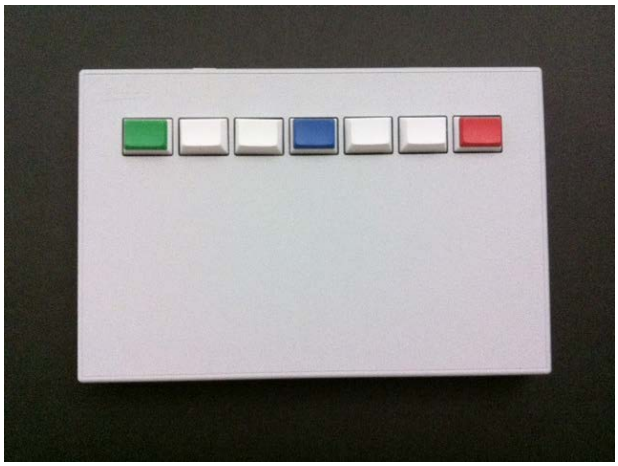

Figure 1. Cedrus model RB-730 button box. Participants pressed the green button to indicate “left” and the red button to indicate “right”.

Table 7. Demographics of N=42 Participants in Experiments 3 and 4

Characteristic	Mean (SD)	Min	Max
Age (n=42)	39.12 (11.7)	21	61
Experience (n=31)	16.22 (11.0)	0	38
Gender			
Male	5 (11.9)		
Female	37 (88.1)		
Language			
English	31 (73.8)		
French	9 (21.4)		
German	1 (2.4)		
Other	1 (2.4)		
Licensed			
Yes	31 (73.8)		
No	4 (9.52)		
NA	7 (16.7)		
Profession			
MD	5 (11.9)		
RN	16 (38.1)		
RPh	8 (19.0)		
Pharmacy Tech.	10 (23.8)		
Pharmacy Student	2 (4.8)		
Consumer	1 (2.4)		
Degree			
MD	5 (11.9)		
RN	14 (33.3)		
RPh	3 (7.14)		
PharmD	5 (11.9)		
BS	1 (2.4)		
Other	9 (21.4)		
None	5 (11.9)		
Dominant Hand			
Right	37 (88.1)		
Left	5 (11.9)		
Prior Participant			
Yes	16 (38.1)		
No	26 (61.9)		

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