

False recognition production indexes in forward associative strength (FAS) lists with three critical words

María Soledad Beato¹ and Jason Arndt²

¹ University of Salamanca and ² Middlebury College (USA)

Abstract

Background: False memory illusions have been widely studied using the Deese/Roediger-McDermott paradigm (DRM). In this paradigm, participants study words semantically related to a single nonpresented critical word. In a memory test critical words are often falsely recalled and recognized. **Method:** The present study was conducted to measure the levels of false recognition for seventy-five Spanish DRM word lists that have multiple critical words per list. Lists included three critical words (e.g., HELL, LUCEFER, and SATAN) simultaneously associated with six studied words (e.g., devil, demon, fire, red, bad, and evil). Different levels of forward associative strength (FAS) between the critical words and their studied associates were used in the construction of the lists. Specifically, we selected lists with the highest FAS values possible and FAS was continuously decreased in order to obtain the 75 lists. **Results:** Six words per list, simultaneously associated with three critical words, were sufficient to produce false recognition. Furthermore, there was wide variability in rates of false recognition (e.g., 53% for DUNGEON, PRISON, and GRATES; 1% for BRACKETS, GARMENT, and CLOTHING). Finally, there was no correlation between false recognition and associative strength. **Conclusions:** False recognition variability could not be attributed to differences in the forward associative strength.

Keywords: False memory, false recognition, DRM paradigm, forward associative strength (FAS).

Resumen

Índices de producción de reconocimiento falso en listas con tres palabras críticas construidas a partir de la fuerza asociativa directa. Antecedentes: los recuerdos falsos han sido ampliamente estudiados usando el paradigma Deese/Roediger-McDermott (DRM). En este paradigma se estudian palabras semánticamente relacionadas a una palabra crítica no presentada. En el posterior test de memoria frecuentemente las palabras críticas se recuerdan o reconocen falsamente. **Método:** en este estudio se han obtenido los niveles de reconocimiento falso para 75 listas DRM en castellano. Las listas incluían tres palabras críticas (e.g., INFIERNO, LUCIFER, SATÁN) simultáneamente asociadas a seis palabras estudiadas (e.g., diablo, demonio, fuego, rojo, malo, mal). Para construir las listas se usaron diferentes niveles de fuerza asociativa directa entre las palabras críticas y sus asociados estudiados. Concretamente, se seleccionaron listas con el mayor nivel de fuerza asociativa posible y progresivamente se fue disminuyendo la fuerza asociativa hasta obtener las 75 listas. **Resultados:** seis palabras por lista, simultáneamente asociadas a tres palabras críticas, fueron suficientes para producir reconocimiento falso. Además, había una amplia variabilidad en el rango de reconocimiento falso obtenido (e.g., 53% para MAZMORRA, PRISIÓN y REJAS; 1% para CORCHETES, PRENDA y TEXTIL). Finalmente, no había correlación entre el reconocimiento falso y la fuerza asociativa. **Conclusiones:** la variabilidad en el reconocimiento falso no se puede relacionar con diferencias en la fuerza asociativa directa.

Palabras clave: memoria falsa, reconocimiento falso, paradigma DRM, fuerza asociativa directa.

It is well known that memory is a reconstruction of the past that is prone to errors. For this reason, current research on human memory includes not only true memory analysis but also investigates the mistakes that occur when people try to remember past events. One of the most widely-used paradigms to examine both true and false memory is the Deese/Roediger-McDermott (DRM) paradigm (Deese, 1959; Roediger & McDermott, 1995). In the DRM paradigm, participants are required to study several words

(e.g., *boy, dolls, female, young, dress, pretty, hair, niece, dance, etc.*), all of them associated with a single nonpresented *critical lure* word (e.g., *girl*; Roediger & McDermott, 1995). In a later memory test, critical lures are often falsely remembered as if they had been studied, which is commonly referred to as false memory. This paradigm has been used extensively to understand the mechanisms underlying false memories, as well as to confirm the robustness of associative false memory illusions (e.g., Alonso, Fernández, Díez, & Beato, 2004; Arndt, 2012a; Beato, Cadavid, Pulido, & Pinho, 2013; Carneiro, Fernández, Díez, García-Marques, Ramos, & Ferreira, 2012; Gallo, 2006; 2010; Jou, & Flores, 2013; Otgaar, Peters, & Howe, 2012; Pimentel & Albuquerque, 2013).

While much research has examined the processes underlying lure errors in the DRM paradigm, less research has explored neural correlates, using functional magnetic resonance imaging (fMRI) or

event-related potentials (ERPs), to examine whether true and false memories share common underlying processes (e.g., Cabeza, Rao, Wagner, Mayer, & Schacter, 2001; Curran, Schacter, Johnson, & Spinks, 2001). In part, this may be because studying the neural correlates of false memory with the DRM paradigm presents challenges for researchers. Specifically, false memory ERP effects, like true memory ERP effects, are commonly only a few microvolts in size (e.g., Boldini, Beato, & Cadavid, 2013), which makes it essential to maximize the signal-to-noise (S/N) ratio in order to obtain reliable ERP waveforms (Luck, 2005). One way to maximize the signal-to-noise ratio is to increase the number of trials that are included in average ERPs for false memories—the more trials that are included in an average ERP waveform, the less noise there will be remaining in that averaged waveform (Luck, 2005). However, the standard DRM paradigm involves presentation of a series of words that are associated with a single critical word. As a consequence, the number of critical words available to form ERP waveforms is considerably lower than the number of studied words. Thus, the signal-to-noise ratio is much better for ERPs of studied words than for ERPs of lures. Given that many ERP-based studies of false memory compare ERPs for studied item hits and critical lure false alarms, this discrepancy in the signal-to-noise ratio complicates the interpretation of such comparisons.

One potential solution to this problem is to increase the number of critical words per list. This solution has been employed in some studies examining ERPs for DRM false memory. Specifically, previous studies sometimes have defined the highest-ranking associates of lures as critical words in order to obtain more trials for critical lure ERP formation (e.g., Miller, Baratta, Wynveen, & Rosenfeld, 2001; Wiese & Daum, 2006). However, this change is not entirely desirable, as it defines words that are not necessarily associated with the presented study items as critical lures, even though the defining characteristic of critical lures in the DRM paradigm is their association with all studied items.

As a way of addressing these limitations, and without forgetting the importance of such lists for ERP-based work, Beato and Díez (2011) created DRM lists that contained six study words, each of which produced the same three critical words in free association (Backward Association Strength, BAS). The results of Beato and Díez's (2011) norming study showed that their DRM lists produced false recognition. Further, there was a wide variability in the effectiveness of the lists in eliciting false recognition (from 4 to 65%), similar to prior norming studies of DRM lists (Stadler, Roediger, & McDermott, 1999). As was the case with prior studies using the DRM paradigm (e.g., Knott, Dewhurst, & Howe, 2012; McEvoy, Nelson, & Komatsu, 1999; Roediger, Watson, McDermott, & Gallo, 2001), BAS was an important factor in determining false memory rates, although BAS could not completely explain the variability found by Beato and Díez with multiple critical words per list. Thus, it is important to explore other factors that may explain additional variability in false memory within the DRM paradigm, which in turn may be useful to researchers using ERP to investigate the electrophysiological correlates of false memory.

In the present work, we employ the same list construction techniques as Beato and Díez (2011), to create 75 lists using the Forward Associative Strength (FAS). The lists contained three critical words that all produced the same six words in free association.

In order to analyze the effectiveness of these lists to increase the signal-to-noise ratio, two hypothetical experiments with twelve-

word lists and one critical word, and the new six-word lists with three critical words, for example, could be compared. Assuming that both experiments had 180 studied words, the following data could be obtained. Experiment 1 would employ fifteen twelve-word lists and would only provide fifteen critical words. In contrast, Experiment 2 would employ thirty six-word lists and would provide ninety critical words.

Moreover, in this study we varied the level of FAS across a wide range of values in order to analyze its relationship with the false memories in the DRM paradigm. Thus, the current normative study (a) will provide a new pool of 75 DRM lists that are useful for studies of DRM false memory with a Spanish-speaking population, (b) will help to understand the role that FAS plays in producing false memory in the DRM paradigm, and (c) will provide a large set of DRM stimulus lists to researchers who wish to study neural correlates of true and false memory, since the lists allow a large number of false recognition observations to be collected with the study of relatively few DRM lists.

Method

Participants

One hundred ninety-five undergraduate native Spanish speakers participated in this study. Their ages ranged from 18 to 38 years ($M = 21.33$), and 86.67% were women. All participants volunteered and thus were not compensated for their time.

Instruments

Seventy-five lists composed of three critical words with Forward Associative Strength (FAS) to the same six associates were constructed for this study (see Table 1). Our goal was to build lists that varied greatly in FAS. Thus, we selected lists with the highest FAS values possible, as well as lists that had continuously lower FAS values using the Fernández, Díez, and Alonso (2009) free-association norms for 4,051 Spanish words. A Perl computer program was designed to search through the 195,187 CUE-TARGET word pairs in the Fernández et al. (2009) free-association norms in order to select groups of three words (critical words) that produced the same six or more associated words with a non-zero probability (i.e., forward associative strength, FAS). The program generated 5,992 such sets.

To select the lists used in this study, we employed similar criteria to Beato and Díez (2011). Specifically, the words had to be associated to critical lures with strength greater than or equal to .01. The FAS values for each critical word (*critical word FAS* hereafter) were determined by the sum of the associative strengths between the critical word and its six associated words. Similarly, the FAS values of each list (*FAS list strength* hereafter) were calculated as the sum of the FAS values for the three critical words (Beato & Díez, 2011; Robinson & Roediger, 1997).

The FAS list strengths used in this study had values between 1.00 and 2.20 ($M = 1.51$; $SD = 0.27$). The 225 FAS values of the critical words ranged from 0.12 to 0.79 ($M = 0.50$; $SD = 0.15$). The 450 studied words had a forward associative strength from the critical words between 0.03 and 1.21 ($M = 0.25$; $SD = 0.21$). Finally, stimulus lists were constructed such that they would have minimal associative strength from the studied associates to the critical words (i.e., Backward Associative Strength, BAS), so that

Table 1

Seventy-five six-word lists with three critical words, sum of the associative strength of the six list words with respect to the three critical words (FAS list), mean percentage of true recognition (TR list) and mean percentage of false recognition (FR list)¹

CRITICAL WORDS: associated words (approximated English translation)	FAS list	TR list	FR list
ARTÍSTICO / LIENZO / PINCEL: cuadro, pintura, arte, pintar, dibujo, pintor (ARTISTIC / CANVAS / BRUSH: picture, painting, art, paint, drawing, painter)	1.95	78.26	18.84
LENTILLAS / OCULAR / ÓPTICA: gafas, ojo, vista, ver, oculista, visión (CONTACT-LENSES / OCULAR / OPTICAL: glasses, eye, sight, see, optometrist, vision)	1.90	76.09	25.36
FUSIL / METRALLETA / RIFLE: arma, guerra, pistola, disparo, muerte, bala (HANDGUN / MACHINE-GUN / RIFLE: weapon, war, pistol, shot, death, bullet)	1.79	66.30	16.67
BAÑERA / GEL / LAVABO: ducha, agua, baño, jabón, limpio, limpieza (BATH / GEL / SINK: shower, water, bathroom, soap, clean, cleaning)	1.78	58.33	16.67
ALIANZA / COMPROMISO / ENLACE: matrimonio, boda, unión, anillo, amor, casarse (ALLIANCE / COMMITMENT / BOND: marriage, wedding, union, ring, love, marry)	1.67	71.38	35.51
ENFURECIDO / ENOJO / INDIGNACIÓN: enfado, enfadado, rabia, ira, cabreo, malestar (ENRAGED / ANNOYANCE / INDIGNATION: anger, angry, rage, ire, wrath, discomfort)	1.63	53.26	3.62
MIERDA / PORQUERÍA / REPUGNANCIA: asco, basura, suciedad, sucio, asqueroso, cerdo (SHIT / CRAP / REPUGNANCE: disgust, trash, dirt, dirty, disgusting, pig)	1.62	81.16	18.84
CONSTIPADO / MUCOSIDAD / RESFRIADO: gripe, nariz, mocos, catarro, pañuelo, frío (TO-HAVE-A-COLD / SNOT / COLD: flu, nose, mucus, catarrh, scarf, cool)	1.58	65.22	26.09
MAZMORRA / PRISIÓN / REJAS: cárcel, celda, barrotes, preso, jaula, libertad (DUNGEON / PRISON / GRATES: jail, cell, bars, prisoner, cage, freedom)	1.57	85.87	52.90
MISA / PLEGARIA / REZO: iglesia, cura, oración, Dios, religión, rezar (MASS / APPEAL / PRAYER: church, priest, orison, God, religion, pray)	1.49	84.06	28.99
CORCHETES / PRENDA / TEXTIL: ropa, pantalón, vestido, camisa, falda, chaqueta (BRACKETS / GARMENT / CLOTHING: clothes, pants, dress, shirt, skirt, jacket)	1.42	92.39	0.72
ANIMADO / EUFÓRICO / JÚBILLO: alegría, alegre, fiesta, feliz, contento, divertido (ANIMATED / EUPHORIC / JOY: cheerfulness, cheerful, party, happy, glad, funny)	1.42	82.25	7.97
ALMOHADA / RELAX / SOFÁ: cama, dormir, descanso, comodidad, sueño, siesta (PILLOW / RELAX / SOFA: bed, to-sleep, break, comfort, sleep, nap)	1.42	67.75	8.70
CODO / EXTREMIDAD / ROTURA: brazo, pierna, hueso, rodilla, cuerpo, pie (ELBOW / TIP / BREAK: arm, leg, bone, knee, body, foot)	1.41	74.64	7.25
DEMONIO / INFIERNO / LUCIFER: diablo, fuego, rojo, Satán, maldad, mal (DEMON / HELL / LUCIFER: devil, fire, red, Satan, wickedness, evil)	1.35	68.84	45.65
LIENZO / ÓLEO / PINCEL: pintura, cuadro, pintar, arte, pintor, dibujo (CANVAS / OIL / BRUSH): painting, picture, paint, art, painter, drawing)	2.20	76.67	15.56
AROMA / ESENCIA / JAZMÍN: olor, flor, perfume, fragancia, colonia, rosa (AROMA / ESSENCE / JASMINE: smell, flower, perfume, fragrance, colony, rose)	1.99	78.52	27.41
ARTICULACIÓN / CODO / EXTREMIDAD: brazo, rodilla, pierna, hueso, mano, cuerpo (JOINT / ELBOW / TIP: arm, knee, leg, bone, hand, body)	1.78	79.26	14.81
CATARRO / CONSTIPADO / ESTORNUDO: gripe, resfriado, tos, mocos, nariz, pañuelo (CATARRH / TO-HAVE-A-COLD / SNEEZE: flu, cold, cough, mucus, nose, scarf)	1.76	82.22	36.30
CAPILLA / ORAR / REZO: iglesia, rezar, misa, cura, religión, cruz (CHAPEL / IMPLORER / PRAYER: church, pray, mass, priest, religion, cross)	1.62	80.74	14.07
PRISA / VELOCIDAD / VELOZ: rápido, coche, rapidez, carrera, tiempo, lento (HURRY / SPEED / FAST: quick, car, rapidity, race, time, slow)	1.59	78.89	30.37
CARIBE / COSTA / SOLEADO: playa, mar, sol, calor, vacaciones, verano (CARIBBEAN / COAST / SUNNY: beach, sea, sun, heat, holiday, summer)	1.58	77.41	8.15
CAÑÓN / FUSIL / RIFLE: guerra, arma, pistola, disparo, bala, fuego (CANNON / HANDGUN / RIFLE: war, weapon, pistol, shot, bullet, fire)	1.55	68.15	13.33
GEL / JABÓN / LAVABO: ducha, baño, limpio, agua, limpieza, lavar (GEL / SOAP / SINK: shower, bathroom, clean, water, cleaning, wash)	1.50	67.41	14.81
CAUTIVERIO / RECLUSIÓN / REJAS: cárcel, prisión, encierro, preso, encerrado, libertad (CAPTIVITY / SECLUSION / GRATES: jail, prison, confinement, inmate, enclosed, freedom)	1.50	75.19	11.85
DESGRACIA / ENTIERRO / FUNERAL: muerte, tristeza, pena, dolor, triste, llanto (MISFORTUNE / BURIAL / FUNERAL: death, sadness, penalty, pain, sad, crying)	1.47	65.93	19.26

¹ For additional information contact the authors

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CRITICAL WORDS: associated words (approximated English translation)	FAS list	TR list	FR list
ANIMADO / JÚBILO / RISA: alegría, alegre, sonrisa, fiesta, feliz, divertido (ANIMATED / JOY / LAUGHTER: cheerfulness, cheerful, smile, party, happy, funny)	1.43	77.78	14.07
ALIANZA / CASAR / COMPROMISO: boda, anillo, matrimonio, unión, pareja, amor (ALLIANCE / MARRY / COMMITMENT: wedding, ring, marriage, union, couple, love)	1.39	72.96	28.89
COSER / MODISTA / TEJIDO: ropa, aguja, tela, lana, hilo, vestido (SEW / DRESSMAKER / FABRIC: clothes, needle, material, wool, yarn, dress)	1.39	76.30	21.48
DESCANSAR / PEREZA / RELAX: dormir, cama, sueño, sofá, siesta, cansancio (REST / LAZINESS / RELAX: to-sleep, bed, sleep, sofa, nap, tiredness)	1.32	77.41	11.85
MUGRE / PORQUERÍA / REPUGNANCIA: asco, suciedad, mierda, basura, sucio, asqueroso (GRIME / FILTH / REPUGNANCE: disgusting, dirtiness, shit, trash, dirty, nasty)	2.12	87.62	14.29
ARTÍSTICO / ÓLEO / PINCEL: pintura, cuadro, pintar, arte, dibujo, pintor (ARTISTIC / OIL / BRUSH: painting, picture, paint, art, drawing, painter)	1.95	74.76	11.43
ANTÁRTIDA / IGLÚ / POLAR: frío, hielo, esquimal, polo, nieve, norte (ANTARCTICA / IGLOO / POLAR: cold, ice, Eskimo, pole, snow, north)	1.79	65.24	13.33
CONSTIPADO / ESTORNUDO / MUCOSIDAD: gripe, nariz, resfriado, mocos, pañuelo, catarro (TO-HAVE-A-COLD / SNEEZE / SNOT: flu, nose, cold, mucus, scarf, catarrh)	1.75	70.48	15.24
BAÑERA / HIGIENE / LAVABO: agua, baño, ducha, limpieza, limpio, jabón (BATH / HYGIENE / SINK: water, bathroom, shower, cleaning, clean, soap)	1.67	63.81	25.71
CAPILLA / DEVOTO / ORAR: rezar, iglesia, religión, cura, misa, Dios (CHAPEL / DEVOTEE / IMPLORE: pray, church, religion, priest, mass, God)	1.64	75.24	12.38
CAÑÓN / FUSIL / METRALLETA: guerra, arma, pistola, disparo, bala, fuego (CANNON / HANDGUN / MACHINE-GUN: war, weapon, pistol, shot, bullet, fire)	1.61	70.00	12.38
CODO / EXTREMIDAD / TENDÓN: brazo, pierna, mano, cuerpo, pie, rodilla (ELBOW / TIP / TENDON: arm, leg, hand, body, foot, knee)	1.48	86.67	3.81
DISCOTECA / ESPECTÁCULO / VERBENA: fiesta, música, baile, luces, diversión, noche (DISCO / SHOW / OPEN-AIR-DANCE: party, music, dance, lights, fun, night)	1.47	55.71	14.29
ASESINAR / CRIMEN / HOMICIDA: asesino, matar, muerte, sangre, cuchillo, cárcel (TO-MURDER / CRIME / HOMICIDAL: assassin, kill, death, blood, knife, jail)	1.43	66.19	26.67
PODIO / TROFEO / VENCEDOR: ganador, premio, ganar, campeón, copa, triunfo (PODIUM / TROPHY / VICTOR: winner, award, to-win, champion, cup, triumph)	1.43	64.29	25.71
CONTENTO / REÍR / RISA: feliz, alegre, alegría, sonrisa, felicidad, chiste (GLAD / LAUGH / LAUGHTER: happy, cheerful, cheerfulness, smile, happiness, joke)	1.42	79.05	23.81
ALIANZA / ENLACE / ESPOSO: matrimonio, anillo, unión, boda, compromiso, amor (ALLIANCE / BOND / HUSBAND: marriage, ring, union, wedding, commitment, love)	1.39	84.29	23.81
COSER / COSTURA / DESCOSIDO: roto, hilo, aguja, pantalón, vestido, dedal (SEW / SEWING / UNSTITCHED: broken, yarn, needle, trousers, dress, thimble)	1.38	81.90	28.57
ALMOHADA / DESCANSO / RELAX: dormir, cama, tranquilidad, colchón, sueño, siesta (PILLOW / BREAK / RELAX: to-sleep, bed, tranquility, mattress, sleep, nap)	1.38	93.81	17.14
MUGRE / REPUGNANCIA / VERTEDERO: asco, basura, mierda, suciedad, sucio, olor (GRIME / REPUGNANCE / LANDFILL: disgusting, trash, shit, dirtiness, dirty, smell)	2.05	86.67	15.56
ARTÍSTICO / LIENZO / ÓLEO: pintura, cuadro, arte, dibujo, pintar, pintor (ARTISTIC / CANVAS / OIL: painting, picture, art, drawing, paint, painter)	1.91	77.78	14.07
CONTENTO / JÚBILO / RISA: alegría, feliz, alegre, felicidad, sonrisa, divertido (GLAD / JOY / LAUGHTER: cheerfulness, happy, cheerful, happiness, smile, funny)	1.82	76.67	20.00
BAÑERA / GEL / HIGIENE: ducha, agua, baño, limpieza, limpio, jabón (BATH / GEL / HYGIENE: shower, water, bathroom, cleaning, clean, soap)	1.69	58.89	21.48
CAPILLA / ORAR / PLEGARIA: rezar, iglesia, Dios, misa, religión, cura (CHAPEL / IMPLORE / APPEAL: pray, church, God, mass, religion, priest)	1.61	77.04	13.33
ASESINAR / HOMICIDA / PUÑAL: asesino, matar, cuchillo, muerte, sangre, dolor (TO-MURDER / HOMICIDAL / PONIARD: assassin, kill, knife, death, blood, pain)	1.61	68.15	25.93
CATARRO / CONSTIPADO / MUCOSIDAD: gripe, nariz, mocos, resfriado, pañuelo, enfermo (CATARRH / TO-HAVE-A-COLD / SNOT: flu, nose, mucus, cold, scarf, ill)	1.60	70.37	24.44

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CRITICAL WORDS: associated words (approximated English translation)	FAS list	TR list	FR list
BATALLÓN / INFANTERÍA / REGIMIENTO: ejército, guerra, soldados, militar, cuartel, batalla (BATTALION / INFANTRY / REGIMENT: army, war, soldiers, military, barracks, battle)	1.57	74.81	14.81
INFIERNO / LUCIFER / SATÁN: diablo, demonio, fuego, rojo, malo, mal (HELL / LUCEFER / SATAN: devil, demon, fire, red, bad, evil)	1.55	82.96	32.59
CASAR / NOVIA / PRETENDIENTE: novio, boda, amor, matrimonio, pareja, compromiso (MARRY / BRIDE / SUITOR: groom, wedding, love, marriage, couple, commitment)	1.50	80.37	20.74
BANDEJA / COMEDOR / MANTEL: comida, mesa, cocina, comer, cena, casa (TRAY / DINING / TABLECLOTH: food, table, kitchen, eat, dinner, house)	1.47	81.48	11.11
MONTE / PRADO / VALLE: verde, montaña, campo, hierba, árbol, bosque (MOUNT / MEADOW / VALLEY: green, mountain, field, grass, tree, forest)	1.47	88.52	25.19
CODO / MÚSCULO / RODILLA: brazo, pierna, hueso, cuerpo, articulación, pie (ELBOW / MUSCLE / KNEE: arm, leg, bone, body, joint, foot)	1.42	74.44	17.78
QUIETUD / RELAX / SOSIEGO: tranquilidad, calma, paz, descanso, tranquilo, cansancio (STILLNESS / RELAX / QUIET: tranquility, calm, peace, break, tranquil, tiredness)	1.38	78.15	9.63
PODIO / TRIUNFANTE / TROFEO: ganador, premio, ganar, campeón, copa, triunfo (PODIUM / TRIUMPHANT / TROPHY: winner, award, to-win, champion, cup, triumph)	1.38	70.37	25.93
ESENCIA / JAZMÍN / OLOR: flor, perfume, aroma, colonia, fragancia, rosa (ESSENCE / JASMINE / SMELL: flower, perfume, aroma, colony, fragrance, rose)	1.31	85.42	37.50
PODIO / TRIUNFANTE / VENCEDOR: ganador, campeón, ganar, premio, carrera, victoria (PODIUM / TRIUMPHANT / VICTOR: winner, champion, to-win, award, race, victory)	1.30	60.42	20.83
BORRACHO / LICOR / WHISKY: alcohol, bebida, ron, beber, fiesta, vino (DRUNK / LIQUEUR / WHISKY: alcohol, beverage, rum, to-drink, party, wine)	1.30	81.94	13.89
DEPRIMIDO / INFELIZ / LLORAR: triste, tristeza, lágrima, pena, depresión, llanto (DEPRESSED / UNHAPPY / CRY: sad, sadness, tear, penalty, depression, crying)	1.21	68.75	34.72
COSTA / PISCINA / PLAYA: agua, verano, sol, calor, vacaciones, relajación (COAST / POOL / BEACH: water, summer, sun, heat, holiday, relaxation)	1.21	75.69	26.39
PLEGARIA / REZAR / RUEGO: Dios, orar, oración, iglesia, pedir, religión (APPEAL / PRAY / ENTREATY: God, implore, orison, church, to-request, religion)	1.21	87.50	29.17
ARREGLO / COSTURA / DESCOSIDO: roto, coser, pantalón, aguja, cosido, vestido (FIX / SEWING / UNSTITCHED: broken, sew, trousers, needle, stitched, dress)	1.20	70.14	26.39
CAÑÓN / DISPARO / ESCOPETA: guerra, pistola, arma, bala, ruido, tiro (CANNON / SHOT / SHOTGUN: war, pistol, weapon, bullet, noise, shooting)	1.12	75.69	33.33
BARRIO / HABITANTE / VILLA: pueblo, casa, ciudad, aldea, lugar, gente (NEIGHBORHOOD / INHABITANT / VILLA: town, house, city, village, place, people)	1.10	62.50	12.50
ALIANZA / NOVIOS / UNIÓN: amor, boda, pareja, matrimonio, compromiso, cariño (ALLIANCE / NEWLYWEDS / UNION: love, wedding, couple, marriage, commitment, fondness)	1.10	72.22	16.67
CORONEL / GENERAL / OFICIAL: ejército, soldado, militar, mando, sargento, jefe (COLONEL / GENERAL / OFFICIAL: army, soldier, military, command, sergeant, chief)	1.10	74.31	31.94
LESIÓN / MULETA / TOBILLO: pierna, dolor, esguince, rodilla, rotura, codo (INJURY / CRUTCH / ANKLE: leg, pain, sprain, knee, break, elbow)	1.01	63.19	27.78
CHARLA / COLOQUIO / TERTULIA: hablar, conversación, amigos, reunión, debate, discurso (TALK / COLLOQUIUM / GATHERING: to-speak, conversation, friends, meeting, debate, speech)	1.01	54.17	12.50
BUTACA / SILLA / TABURETE: sentarse, asiento, descanso, sillón, cocina, madera (ARMCHAIR / CHAIR / STOOL: sit, seat, break, easy chair, kitchen, wood)	1.00	60.42	15.28
CRIMINAL / CULPABLE / SOSPECHOSO: cárcel, asesino, ladrón, delito, malo, preso (CRIMINAL / GUILTY / SUSPECT: jail, assassin, thief, crime, bad, prisoner)	1.00	80.56	30.56

results were not affected by variation in BAS (for a discussion about the types of links between associated words, see Nelson, Dyrdal, & Goodmon, 2005). Indeed, by dividing 75 lists into two groups based on median split of FAS, we confirmed that high and

low FAS groups had similar BAS (.247 and .341, respectively), $t(73) = -1.520$; $p = .133$. The BAS list strengths had values between 0.01 and 1.49 ($M = 0.30$, $SD = 0.27$), while the BAS values of the critical words ranged from 0.00 to 1.45 ($M = .10$, $SD = .17$).

Additionally, we included unrelated distractors that were the six associates ('unrelated distractors') and three critical lures ('unrelated critical-distractors') from 5 non-studied DRM lists (Beato & Díez, 2011) on the memory tests.

Given that there were repeated words across the 75 lists, we distributed them into five different groups of 15 lists (*n* per list ranged from 24 to 46 individuals), such that there were no repeated words within a given group. Thus, study lists were 90 words in length (15 lists × 6 studied associates per list). Study items were presented blocked by DRM list, and the order of presentation was randomized.

The recognition test for each of the five study lists included 180 words: the 90 studied associates, the 45 critical words related to the studied associates, and 45 distractors (15 unrelated critical-distractors and 30 unrelated distractors). Three random orders of test items were constructed for each of the five recognition tests following the criteria proposed by Graham (2007).

Procedure

Participants were run in groups of 7-17 individuals, and procedure was similar to Beato and Díez (2011). Specifically, participants were informed that the purpose of the study was to examine their memory and math skills. They would listen to fifteen six-word lists in a male voice (one word every two seconds). The associates within each list were arranged in decreasing order according to their forward associative strength with the critical words. Following the presentation of each list they would be asked to solve simple arithmetic problems for one minute.

At the conclusion of the study phase, participants received instruction for the recognition memory test. Participants were presented with two sheets of paper on which the test items were printed, along with check-boxes (YES, NO) next to each word, which they could use to indicate their responses. Participants were asked to read each word and decide whether it was among the studied words. They were asked to respond in the order they appeared on the recognition test, were asked to respond to all words, and were told that they should not go back to change an answer once they had responded to a word. There was no time limit for the recognition memory test.

Data analysis

The results are presented as means of percentage of true recognition, false recognition, and intrusions, with their respective standard deviations (*SD*). A repeated-measures one-way analysis of variance (ANOVA) was carried out to analyze false recognition production in the new DRM lists. Subsequently, appropriate post-hoc analysis was performed. Furthermore, correlational analysis was used to determine a possible relationship between TR, FR, and FAS. A value of $p < .05$ was considered statistically significant. In the analysis, partial eta squared (η^2) indicates effect size.

Results

A repeated-measures one-way analysis of variance (ANOVA) (Type of Word: studied words, critical words, unrelated critical-distractors and unrelated distractors) revealed a significant main effect of Type of Word, $F(3, 582) = 3020.50$; $MSE = 115.715$; $p < .001$; $\eta^2 = .940$. Post-hoc tests showed that hits to studied word

(true recognition) ($M = 74.39$; $SD = 11.98$; range: 41.11-96.67) were higher than false alarms to critical words (false recognition) ($M = 20.35$; $SD = 12.54$; range: 2.22-80.00), to unrelated critical-distractors ($M = 3.35$; $SD = 4.90$; range: 0.00-20.00), and to unrelated distractors ($M = 1.88$; $SD = 2.89$; range: 0.00-13.33) ($p < .001$). There were also significant differences between false alarms to critical words and both unrelated critical-distractor and unrelated distractor items ($p < .001$), confirming that critical words produced above-baseline levels of false recognition.

In order to determine if there was a relationship between FR and FAS, two correlation analyses were conducted. In the first analysis, the 225 critical words were used as the unit of analysis. First, no significant correlation was found between percentage of critical word FR and critical word FAS ($r = .082$, $p = .220$). Similarly, in the second analysis, including the mean values of the 75 lists, we found no correlation either between TR and FR ($r = .088$, $p = .453$), or FR and FAS ($r = -.165$, $p = .159$).

Discussion

The present normative study determined the false recognition (FR) produced by 75 three-critical-word DRM lists in Spanish with six studied words.

The level of true recognition (TR) observed in our study (74.39%) was similar to Beato and Díez (2011) (74%), who used the same number of words in the study phase, and who also presented six-word DRM lists. Likewise, the percentage of false alarms (unrelated distractors and unrelated critical-distractors, 2.62%) was, again, similar to these authors (3%). Therefore, there was high precision in true recognition as well as low levels of unrelated false alarms.

Furthermore, results showed that there was wide variability in the degree to which these lists elicited false recognition. Examining false recognition at the level of each list showed wide differences in the mean FR of the lists. Some lists yielded very little false recognition, such as the list with the critical lures BRACKETS, GARMENT, and CLOTHING (0.7%), whereas other lists produced high levels of false recognition, such as the list with critical lures DUNGEON, PRISON, and GRATES (53%). In previous studies, FR ranged from 4% to 65% (Beato & Díez, 2011), from 26% to 100% (Anastasi, De Leon, & Rhodes, 2005), or from 27% to 84% (Stadler et al., 1999). Overall, the mean false recognition for the seventy-five lists was 20%. Similarly, Beato and Díez (2011) obtained 27% employing 60 six-word BAS lists and their corresponding three critical words.

Evaluating false recognition at the level of each critical word also illustrates that false recognition was highly variable. Specifically, no participant incorrectly recognized TRAY, CARIBBEAN, BRACKETS, MISFORTUNE, HOMICIDAL, JASMINE, JOY, DRESSMAKER, SNOT, LAZINESS, SUITOR, BREAK, TENDON or CLOTHING, while the critical word PRISON was falsely recognized 91% of the time. Similar variability in FR has been observed in previous studies, in both Spanish and English, as well as across lists that varied in BAS (e.g., Anastasi et al., 2005; Beato & Díez, 2011; Stadler et al., 1999).

According to correlation analysis, FR was not related to the level of FAS of the lists, nor was FR for individual critical words related to critical word FAS levels. The lack of correlation between FR and FAS in both analyzes suggested that the false recognition level was not directly determined by the differences

in forward associative strength of this specific type of DRM lists. These results are consistent with results obtained in several previous studies examining false recall and false recognition (e.g., Gallo & Roediger, 2002; Roediger et al., 2001), while they are inconsistent with other studies (e.g., Arndt, 2012b; Brainerd & Wright, 2005), in all cases using FAS lists with only one critical word per list.

The DRM paradigm is currently one of the most frequently used procedures in the false memory studies. Reviewing previous literature on false memory, we found that one methodological obstacle in studies that examined event-related potentials (ERPs) and functional magnetic resonance imaging (fMRI) for false recognition was the number of observations researchers were able to generate for critical lures. In standard DRM word lists, there is only one critical word per list, making it difficult to carry out a robust statistical analysis of the brain activity associated with

false recognition. In an attempt to solve this problem, we created a new pool of 75 DRM lists. These lists serve to study false memory ERPs and fMRI, and to study DRM false memory with a Spanish-speaking population. Empirically determined levels of false recognition from this study allows us to assert that with this methodology it is possible to create DRM lists with reasonably high levels of false recognition. Thus, the lists provide a large number of false recognition observations with the study of relatively few words per list. For the first time, the present work provides DRM lists with several critical lures per list, where we know exactly the forward associative strength between the critical words and the list words, which could be especially useful to study false memory by means of electroencephalographic techniques. As limitations of this work, it is necessary to point out that this study was performed using only Spanish population and future research could be done with other populations.

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