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Negative mood state impairs false memory priming when problem-solving

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Abstract

The aim of this study was to investigate the effect of emotional mood states on the ability to create effective primes using the recently developed false memory priming paradigm. A negative or positive mood state was induced before Deese/Roediger-McDermott (DRM) list presentation. A further control group experienced no mood induction. Participants were then presented with Compound Remote Associate Task (CRAT) problems, half of which had been primed by the previous DRM lists whose critical lure was the solution to the CRAT problem. The results of this study showed that induction of a negative mood state not only impaired recall of critical lures but also diminished their effectiveness as primes for solving CRAT problems. In contrast, for both positive mood and control conditions, the false memory priming advantage was evident, with a higher proportion of primed problems solved in comparison to those not primed. Findings are discussed in relation to the role of affect on semantic activation and the adaptive consequences of false memories.

Key words: False memory, problem solving, affective mood state, DRM paradigm, priming

Negative mood state impairs false memory priming when problem-solving

Negative mood states have been linked to poor decision-making and problem-solving abilities (Arkes, Herren, & Isen, 1998), deficits in attention (Joormann & Gotlib, 2007), and memory impairments (Blaney, 1986). Concerning the latter, studies have previously examined the effect of mood on true memories, but research on the effects of negative mood on false memories has just begun. A robust method used to examine false memories in this line of research is the Deese/Roediger-McDermott (DRM) paradigm (Deese 1959; Roediger & McDermott, 1995). Here, participants are presented with list items (e.g., *table, sit*, *couch, desk*) that are all highly associated with a non-presented critical lure item (e.g., *chair*). After presentation, participants are asked to recall or recognize the list items in subsequent memory tests. A false memory is recorded if the participant reports the thematically related but non-presented critical lure. These false memories are considered to be spontaneous, occurring automatically and without conscious awareness (Howe, Wimmer, Gagnon, & Plumpton, 2009). According to the associative activation theory (Howe et al., 2009) they occur due to automatic spreading activation through associative networks. Activation from concepts contained within the lists spreads to related but unpresented concepts in memory. Related words are then activated at encoding and falsely recalled at retrieval.

Storbeck and Clore (2005) conducted two experiments using the DRM paradigm. Temporary mood states were induced prior to encoding the DRM lists. Results showed that negative affect reduced false memories, while positive affect produced similar levels of false memories as control conditions. Storbeck and Clore hypothesised that affective mood states could influence the production of false memories.. They argued that negative affect was associated with more item-specific processing of information leaving relational processing somewhat impaired, something that has been found to increase rates of true recollection and reduce false memories (Howe, 2008). In comparison, the positive affect provided feelings of efficacy, which validates the use of relational processing styles. Such processing coupled with a reduced item-specific approach leads to increases in false recollection (Howe, 2008). As mentioned earlier, for adults at least, associative activation occurs automatically and without conscious awareness (Howe et al., 2009). Relational processing allows for this automatic and unconscious activation, while item-specific processing is more controlled, thus, inhibiting the automatic spreading activation, necessary for false memory production in the DRM paradigm.

The influence of emotions and mood on cognitive processing also extends to problem solving. For instance, research has shown that individuals in a positive mood produce more unusual associations in a word association task (Isen, Johnson, Mertz, & Robinson, 1985), are able to form more inclusive categories in a sorting task (Isen & Daubman, 1984), and can facilitate creativity on Duncker's (1945) candle task and Mednick, Mednick, and Mednick's (1964) Compound Remote Associate Task (CRAT). A study by Bolte, Goschke, and Kuhl (2003) examined the influence of affective mood state on the ability to make intuitive judgments about the coherence of a word triad. Bolte et al. (2003) presented participants with word triads (e.g., *playing, credit*, *report*), and asked participants to decide whether they were coherent (shared a common solution word- *card*), or whether they were incoherent, with no common solution word. In Experiment 2, a positively induced mood improved intuitive coherence judgments, whereas a negative mood impaired performance to chance level.

The theoretical framework that underlies these findings follows a similar explanation to that used in the false memory literature. In what Bolte et al. (2003)

referred to as the *affect-modulation hypothesis*, positive affect promotes global processing and results in the automatic spreading activation to weak associates. Spreading activation improves the ability to solve word triads and make intuitive coherence judgements. In contrast, the more item-specific processing associated with negative affect, restricts the automatic spread of activation to close associates and impairs the ability to solve word triads and make intuitive coherence judgements.

CRAT problems require the process of spreading activation through semantic networks until the target concept (word) has been activated (Bowden, Jung-Beeman, Fleck, & Koumios, 2005). Aiding the associative activation and "priming" the target concept has been the recent interest of research by Howe and colleagues (e.g., Howe, Garner, Charlesworth, & Knott, 2011; Howe, Garner, Dewhurst, & Ball, 2010; Howe, Garner, & Patel, 2013). These studies have shown that false recall of critical lures can prime solutions to CRAT problems when the solution word is also the critical lure. Typically, participants are presented with DRM lists whose critical lures are primes for half of the to be solved CRATs. Results have shown that when participants recall the critical lure, they are more likely to solve the corresponding CRAT and do so more quickly than those that were not primed. Importantly, previous research has also shown that the priming effect is not just an artifact of increased activation of a critical lure at test. Even in the absence of the recall task, participants still performed better on CRATs that were primed by a critical lure belonging to the presentation of a prior DRM list (Howe et al., 2010, 2011, 2013). Thus, the priming advantage is likely due to participants having generated the critical lure during list encoding and it is the false memory generation that is the source of these priming effects.

Howe and colleagues situated these findings in the emerging adaptive view of memory illusions (see Howe, 2011, for a review). Previous research has shown a memory benefit for survival information and survival processing (Nairne, 2010) that has now been extended to the false memory literature. Howe and Derbish (2010, 2014) argued that because false memories are formed by the same reconstructive memory system, survival-related processing of information that primes highly interconnected concepts and promotes relational processing will inevitably lead to more false memories for survival related information. The recent false memory priming effect seen with CRATs could be an example of this adaptive function of memory (both true and false) as it serves to prime complex problem solving. Indeed Klein, Cosmides, Tooby and Chance (2002) proposed that implicit priming serves as an adaptive function in that memory serves to support future problem solving. This is evidenced in recent research by Howe and colleagues, where false memories function to prime and aid problem solving (Howe et al., 2010, 2011, 2013).

Here we see that the byproduct of memory activation can provide significant advantages to more complex cognitive processes such as insight-based problem solving. However, if processing of information were more controlled and item-specific in nature, unlike what we see with survival processing, would the inhibited associative activation not only impair false recall but also impair the subsequent ability to solve CRAT problems? We know that affective mood states influence processing conditions. Positive affect promotes relational processing and automatic spreading activation, whereas negative affect inhibits relational processing and leads to more controlled, item-specific processing that impairs semantic association and spreading activation. A mood state that impairs relational processing will ultimately inhibit survival processing and hinder the adaptive memory consequence for future problem solving. Thus, the question is whether the use of a mood induction technique during DRM study-recall phase not only impair or enhance, depending on mood state, false memory production but also the ability to use false memories to aid problem solving on subsequent CRATs?

In order to investigate this question, participants completed DRM study-test trials while in a positive or negative mood state. A control condition was also used to aid comparison with previous research. All participants completed a series of CRAT problems, half of which had their solution primed by the associated critical lure of the DRM lists, and half of which had not been primed. As previous research has shown, a negative mood state should be associated with more item specific processing which could hinder automatic associative activation, thus not only reduce false recall, but also reduce the chance that the critical lure can be accessed and used to prime the CRAT problem. This will lessen the priming advantage and lead to similar levels of problem solving across both primed and unprimed CRATs. As positive mood states typically enhance relational processing and thus automatic spreading activation, the priming effect should occur, and problems will be solved more readily and more quickly when primed than not primed.

Method

Participants.

Seventy-two undergraduate students (47 females) aged 18-45 (*M* =19.85, *SD* = 4.09) participated in this study for course credit.

Design and Stimuli.

The experiment followed a 3(mood condition: Positive, Negative, and Control) x 2(Prime type: false memory prime vs. unprimed) design with repeated measures on the second factor. During the DRM study-recall stage participants were randomly assigned to one of 3 mood conditions, Positive, (*n* = 22) Negative, (*n* = 26) and Control (*n* = 24).

Mood induction. Mood was induced using two five-minute video clips. Film clips were chosen as they are considered to produce more complex emotional states (Aldao, 2013). The negative mood group watched the final scene of the movie *The Champ,* while the positive mood group watched a comedy sketch from *Live at the Apollo* (see Rottenberg, Ray, & Gross, 2007, for films that elicit emotion). The control group began the study in their natural mood state. Participant's mood was assessed using the Self-Assessment Manikin scale (SAM; Bradley & Lang, 1994). The SAM is a non-verbal pictorial assessment technique that uses a 9-point Likert scale to directly measure a person's affective state. Low values represent a negative mood, while high values represent a positive mood. Mood measures were taken before and after the initial film clip to ensure successful mood induction. Participants in the control condition completed this before beginning the study phase for a base line measure of their natural mood state. For comparative purposes, it should be noted that neutral moods are generally slightly higher than the midpoint of the scale (e.g., 6.20).

DRM and CRAT stimuli. Eight CRAT problems were taken from Bowden and Jung-Beeman (2003) and considered to be of medium difficulty according to normed solution rates (average normed solution rate = 60.63%). Each CRAT consisted of three words, all of which required a single word to create a compound word or phrase. For example, *rocking, wheel, high,* could all be solved by the word *chair* (DRM lists and associated CRAT problems can be found in the Appendix). The eight chosen DRM lists consisted of 12 associates to the critical lure that also acted as the solution word for the selected CRAT problems. DRM lists were taken from Roediger & McDermott (1995) and randomly divided into two sets of four. Each participant was shown one set of lists. This allowed for 4 CRAT solutions to be primed by the critical lures and four to remain unprimed. Normed solution rate of CRATs and backward associative strength (BAS) were equated across sets. To avoid any mood congruency effects that may have inflated critical lures in the negative and positive mood conditions (see Ruci et al., 2009), DRM lists with neutral valance were chosen (M = 5.85). Valence ratings were taken from Affective Norms for English Words (ANEW: Bradley & Lang, 1999).

Procedure

After mood induction and assessment were complete, participants were presented with four DRM lists in randomised order. Each list was recorded and presented to the participant verbally. At the end of each list participants completed a distractor task (complete basic sums for 30s) and then recalled as many words as they could remember from the list. On completion of the study-test trials participants were provided with verbal instructions on how to solve the CRATs followed by two practice CRAT problems and the 8 test CRATs. Each CRAT was presented on the computer screen, in a random order. When participants knew the solution they were instructed to press ENTER and input their word. Participants were allowed multiple attempts at solving the CRAT, but if they were unable to solve the problem after 60s, the computer programme would provide feedback on the correct answer and move on to the next problem.

Results

Mood-manipulation Check

For the mood manipulation check mood assessment scores taken pre and post video presentation were compared for negative and positive mood groups using a 2(Mood Condition: Positive vs. Negative) x 2(Valence score: Before vs. After video presentation) mixed factor ANOVA with repeated measures on the second factor. A significant interaction, $F(1,46) = 57.35$, $p < .001$, $\eta_p^2 = .56$ was further analysed using Bonferroni pairwise comparisons. For the negative mood group, valence significantly decreased pre (*M* = 6.31, *SD* =1.93) and post (*M* = 3.73, *SD* = 1.63) video ($p < .001$), and increased for the positive mood group (*M* = 6.86, *SD* = 1.49 vs. *M* = 7.77, *SD* = 1.02, $p < .05$). A mood check to include all three mood conditions (the control group did not see a video presentation thus a valence score was only recorded before the onset of the study-test DRM phase) showed a significant effect, $F(2,69) = 59.93$, $p < .001$, $\eta_p^2 = .64$ whereby mood assessment was higher for positive compared to negative, (*M* = 7.77, *SD* = 1.02 vs. *M* = 3.73, *SD* = 1.63, $p < .001$), and control compared to negative (*M* = 7.08, *SD* = 1.38, $p < .001$), but no difference between positive and control ($p = .22$).

False and True Recall

False recall of critical lures. A one-way analysis of variance (ANOVA) was conducted to examine the effect of mood-group (positive, negative, and control) on recall of critical lures (CLs). The main effect of mood was significant, $F(2,69) = 6.91$, $p < .05$, $\eta_p^2 = .17$. Further analysis of pairwise comparisons revealed that both positive (*M* = .33, *SD* = .16) and control (*M* = .40, *SD* = .23) mood groups recalled significantly more critical lures than the negative mood group (*M* = .19, *SD* = .19, $p < .05$ for both).

True recall. A second one-way ANOVA showed no significant difference in correct recall between positive (*M* =.56, *SD* = .08) negative (*M* =.61, *SD* = .13) and control (*M* =.59, *SD* = .10) mood groups, $F(2,69) = 1.11$, $p = .34$, $\eta_p^2 = .03$. An effect not unexpected given that item-specific processing is available for veridical recall in the negative mood condition (Storbeck & Clore, 2005).

CRAT Problem Solving

Both CRAT solution rates (proportion correctly solved) and mean CRAT solution times (in seconds) were analysed using a 3(Mood Condition: Positive, Negative, and Control) x 3(Prime Type: Primed CL vs. Primed no CL vs. Unprimed) mixed factor ANOVA with repeated measures on the second factor. Here, primed CRAT problems were conditionalised on whether participants had produced the critical lure during recall (i.e., Primed CL = critical lure produced and Primed/no CL = no critical lure produced). Due to the conditionalization of the Prime Type for analysis, data was only included if a CL was produced at the DRM study-test trials (Positive n = 21, Negative n = 18 and Control n = 21).

Solution rates for CRATs. There was a significant main effect of Prime type, $F(2, 114) = 7.18$, $p < .001$, $\eta_p^2 = .11$, but no significant main effect of mood, $F(2,57) = 1.73$, $p = .19$, $\eta_p^2 = .06$. However, there was a significant Mood x Prime Type interaction, $F(4,114) = 2.59$, $p < .05$, $\eta_p^2 = .08$. Further analysis of the simple main effects (SMEs) revealed a significant prime effect for positive mood, $F(2,40) = 6.30$, $p < .05$, $\eta_p^2 = .24$ and control groups, $F(2,40) = 6.27$, $p < .05$, $\eta_p^2 = .24$, whereby more CRATs were correctly solved in the primed CL compared to primed no CL and unprimed conditions for both groups. However, there was no effect of priming for the negative mood condition, $F(2,34) = .18$, $p = .84$, $\eta_p^2 = .01$ (see Figure 1). Solution rates for both positive mood and control conditions show a similar pattern to that found in previous research, whereby, more CRATs were solved when the CL prime was produced during the study-test DRM phase. For the negative mood group, not only were fewer critical lures produced during the study-test trails, but when they were produced, they led to fewer primed solutions compared to the positive mood and control conditions.

Solution times for CRATs. Solution times were calculated and analysed where CRATs were solved in all three priming conditions. Analysis of solution times (in seconds) for CRATs revealed a significant main effect of prime type, $F(2,74) = 4.07$, $p < .05$ $\eta_p^2 = .10$, with faster solution times in the primed CL ($M = 8.30$, $SD = 3.71$)

compared to unprimed (*M* = 13.80, *SD* = 10.18 $p < .05$) and primed no CL (*M* = 12.62, *SD* = 9.69, although this was marginal, $p = .06$) conditions. There was no main effect of mood condition, $F(2,37) = .22$, $p = .80$, $\eta_p^2 = .01$, and no Mood x Prime Type interaction, $F(4,70) = .51$ $p = .73$, $\eta_p^2 = .03$ (see Table 1). Faster solution times for CRATs primed by a critical lure supports findings from previous research (e.g., Howe et al., 2010, 2011, 2013). There was no significant Mood x Prime Type interaction, however this is expected, as solution times were analysed only where CRATs were solved in all three priming conditions.

Discussion

The aim of this study was to examine the influence of mood state on false memories and the subsequent effect this may have on the recently discovered priming advantage for insight-based problem solving. First, the results from this experiment support previous findings that claim affect can influence false memory production in the DRM paradigm (e.g., Storbeck & Clore, 2005). Participants in the negative mood group produced fewer critical lures at recall in comparison to the positive mood and control groups. These results are in line with current theories that claim negative affect triggers item-specific processing. Encoding under such conditions inhibits automatic and unconscious spreading activation to related associates reducing the activation of the critical lure. In comparison, positive affect triggers relational processing, which enhances automaticity and the unconscious spreading activation to related critical lures increasing false memory production. Akin to previous findings (e.g., Storbeck & Clore, 2005) there was no difference in false recall between the positive affect and control groups. Typically, control groups display quite a positive affective state that may not differ to a positively induced mood. Furthermore, relational processing is considered to be the default processing style for any nonnegative emotional state (see Storbeck & Clore, 2005).

With a negatively induced mood, impaired automatic associative activation not only reduces the production of critical lures but also prevents those critical lures from coming to mind in subsequent problem solving. That is, the critical lure, when produced in the negative mood condition, did not act as a successful prime as negative affect induced prior to learning promotes item-specific processing that inhibits automatic associative activation. This reduction in activation of related concepts in memory also impairs access to the critical lure during subsequent problem solving. This led to solution rates that were identical to conditions in which there was no priming. For both positive mood and control conditions, the priming advantage was evident and significantly more primed problems were solved than those that were not primed. These conditions promote the use of relational processing that leads to the automatic and unconscious activation of semantic associates. This heightened activation of the critical lure primes the subsequent solution to the CRAT problem. These findings support and extend the recent research by Howe and colleagues that false memories facilitate problem solving in CRATs due to spreading activation in semantic networks (e.g., Howe et al., 2010, 2013).

Speed of problem solving was also faster when primed than when not primed. However our solution time data showed no interaction with mood state. This is not unexpected, as solution times for participants were only analysed where CRATs were solved in all three priming conditions. Coupled with typically large variances in response times (see Standard Error values in Table 1), this may require further investigation. However it is unclear what the effect of mood state on priming will be. For example, previous research has shown that participants respond faster (in an evaluation or category selection task) in the positive compared to negative mood groups when primes are affectively and semantically congruent compared to incongruent. Note however, this is a comparison of the priming effect (congruent words allow for faster responses then incongruent words) and not just the effect of mood state per se (Storbeck & Clore, 2008).

In relation to previous research, it appears that a negative mood state can impair priming due to item-specific processing that inhibits automatic activation of associative networks. In comparison, situations that promote more relational processing further facilitate the false memory priming effect. For example, Howe et al. (2013) found that false memories for survival-related information made better primes for problem solving than neutral false memory primes. We know that survival related processing of information primes networks of highly interconnected concepts that results in high false memory rates for survival information. This in turn allows for better access to false memories during later problem solving, highlighting the adaptive, functional nature of memory. From a spreading activation perspective, survival processing makes for better priming due to the promotion of relational processing and strongly interrelated concepts. In contrast, the present findings demonstrate that processing (neutral) information in a negative mood leads to a reduction in priming due to impaired relational processing and automatic, associative activation.

It is perhaps key to note here that even though survival relevant material can be negative in valence (Howe et al., 2013), it can still enhance the automatic activation of associative networks, increasing critical lure production and access to these critical lures during later problem solving. In comparison, a negative mood hinders the priming effect due to the reliance on item specific processing that impairs associative activation and later access to critical lures. There is an important distinction here – in survival processing the stimuli are highly interrelated and by their nature, relevant to the self and congruent to a survival processing encoding state. This heightens the activation of the survival congruent stimuli through excitation of the related semantic network. This increases the likelihood that related but non-presented information becomes activated and subsequently falsely remembered at test, a finding consistent with Semantic Network Theory (Bower, 1981). What we have yet to examine is a mood congruent effect in the false memory priming advantage. Based on these findings and those from previous studies (Ruci et al., 2009), negative mood may be linked to an increase in activation level for negatively relevant concepts that could in turn lead to enhanced accessibility of this information in memory (Howe & Malone, 2011). This will require further investigation.

These findings, along with others (e.g., Storbeck & Clore, 2005, 2008) support assumptions that affect influences the accessibility of semantic associations in memory. More specifically negative mood can hinder the relational processing that usually facilitates the automatic unconscious spreading activation to relevant semantic concepts and reduce access to relevant primes for later problem solving. This reduction in accessibility to semantic associations provides further support for the theoretical explanation of false memory priming effects. That is, relational processing enhances automatic spreading activation to related semantic networks and heightens accessibility to related, but not presented words. The end result being that a false memory can aid problem solving and prime the solution to an insight-based problem. To conclude, this research adds to the literature on the more positive consequences of false memory production, in that we can use them to aid and prime the solution to complex insight based problems. Not only does this research demonstrate the powerful nature of our reconstructive memory system (Howe, 2011), it is a welcome relief from research that typically refers to false memory production as a negative consequence of human cognition (e.g., errors in eyewitness testimonies).

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Table 1. *Mean solution times as a function of mood condition and prime type (primed vs. unprimed).*

	Mood Condition		
	Negative	Positive	Neutral
Prime CL	8.19 (1.14)	8.36 (.95)	8.32 (1.06)
Prime no CL	9.73 (2.95)	14.15 (2.44)	13.19 (2.71)
Unprimed	15.39 (3.13)	13.88 (2.60)	12.36 (2.88)

Note: SE in parentheses

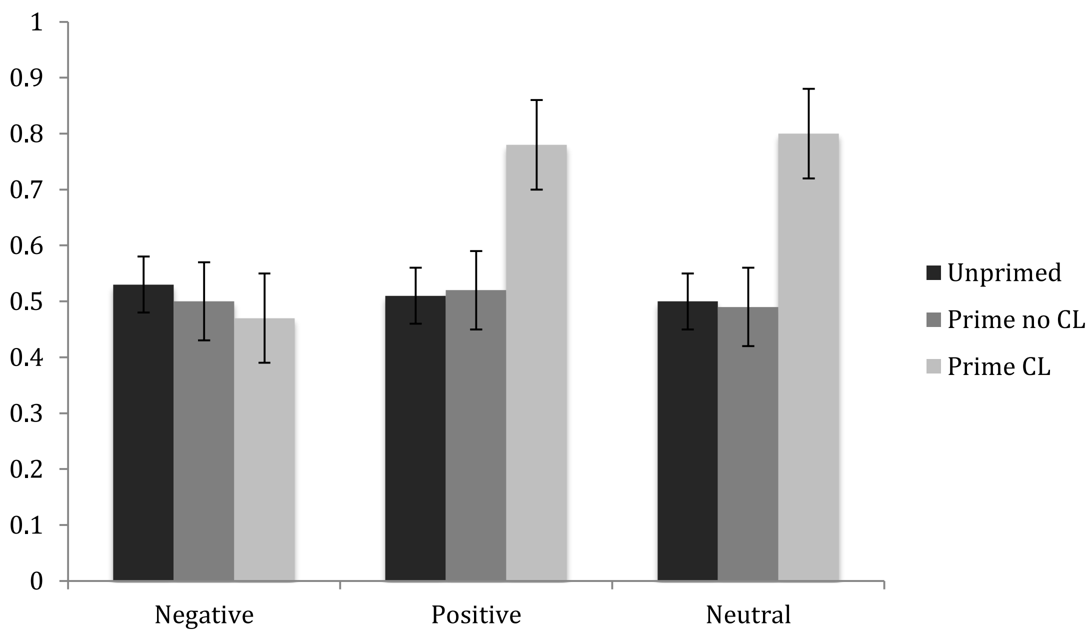

Figure 1. Mean solution rates as a function of mood condition and prime type. Error bars represent standard error (SE).

APPENDIX

DRM lists and associated CRAT problems (critical lure/CRAT solution in CAPS)

CRAT Problem	DRM list
chase/police/toy	CAR - truck, bus, automobile, vehicle, drive, jeep, Ford, keys, garage, highway, van, taxi
salad/bowl/juice	FRUIT - apple, vegetable, orange, kiwi, citrus, ripe, pear, banana, berry, cherry, basket, cocktail
shop/washer/frame	WINDOW - door, glass, pane, shade, ledge, sill, house, curtain, view, breeze, screen, shutter
leg/wheel/high	CHAIR - table, sit, seat, couch, desk, recliner, sofa, cushion, swivel, stool, rocking, bench
knife/tip/pal	PEN - pencil, write, fountain, leak, quill, Bic, scribble, crayon, cross, marker, cap, letter
drinking/tea/cake	CUP - mug, saucer, measuring, coaster, lid, handle, coffee, soup, drink, plastic, sip
football/flannel/vest	SHIRT - blouse, sleeves, pants, tie, button, shorts, polo, collar, pocket, belt, linen, cuffs
base/territorial/boot	ARMY - Navy, soldier, United States, rifle, air force, military, Marines, infantry, captain, war, uniform, combat