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An interactive activation and competition model of person knowledge, suggested by proactive interference by traits spontaneously inferred from behaviours

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People unconsciously and unintentionally make inferences about others' personality traits based on their behaviours. In this study, a classic memory phenomenon – proactive interference (PI) – is for the first time used to detect spontaneous trait inferences. PI should occur when lists of behaviour descriptions, all implying the same trait, are to be remembered. Switching to a new trait should produce 'release' from proactive interference (or RPI). Results from two experiments supported these predictions. PI and RPI effects are consistent with an interactive activation and competition model of person perception (e.g., McNeill & Burton, 2002, *J. Exp. Psychol.*, *55A*, 1141), which predicts categorical organization of social behaviours based on personality traits. Advantages of this model are discussed.

Our social environment is replete with behavioural information that demands our attention, understanding, and interpretation. Fortunately, most of the time we are able to complete these massive tasks in implicit snap judgments. Upon learning that 'Jeff earned a PhD at 22', people immediately infer that Jeff is *smart.* Such attributions of personality traits – spontaneous trait inferences (STIs) – occur without intention or conscious thought and take place online at encoding (Uleman, Hon, Roman, & Moskowitz, 1996; Winter & Uleman, 1984). To detect STIs, researchers tap implicit knowledge (see Uleman, Rim, Saribay, & Kressel, 2012; for a review).

Past research suggests that person-based knowledge is structured categorically (Smith, 1998). Spontaneously inferred traits may provide a relevant set of such categories, with trait-diagnostic behaviours being the stimuli that are categorized. Past work on STIs has considered only single behaviours, and the traits they imply, in isolation. But most knowledge of people involves multiple categories and relations among them. How might such complex information be organized in mental representations of people? One set of

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possibilities is provided by interactive activation and competition (IAC) models of person perception that incorporate personal identity information such as names and faces, in addition to traits and behaviours.

STIs and the IAC model

One architecture for such a model organizes person-related categories into four major levels from concrete to abstract: The input or feature level, and identification, scenario, and conceptual or meaning levels (Read & Miller, 1998). Information on the *feature* level is mainly perceptual, such as one's hair colour. The *identification* level contains unique person-identifying information such as faces and names. Typical *scenario* information includes descriptions of behaviour and answers to the episodic questions of 'who', 'when', 'what', 'where', and 'how'. The *conceptual* level includes the most abstract features that require social inferences, such as traits and relationships. On each level, information-processing units with common themes cluster together to form a pool of units. Within each pool, units are connected via inhibitory links, whereas links between units in different pools are excitatory. All links connecting the units are bidirectional. This model can represent a wide variety of social perception phenomena. See Read and Miller (1998) for more detail.

Another IAC model was developed to account specifically for data from studies of the recognition of familiar people's faces (Burton, Bruce, & Hancock, 1999; Burton, Bruce, & Johnston, 1990). One variant includes person identification nodes (PINs), which serve as the single points of access to stored social knowledge of familiar individuals (McNeill & Burton, 2002). The PINs connect to lower-level face recognition units (FRUs) and name recognition units (NRUs), and also to higher-level semantic information units (SIUs) representing information such as occupations and nationality. Units of a particular kind (e.g., FRUs) form pools with bidirectional inhibitory links between them, so that the activation of one face inhibits the activation of other faces. There are mutual excitatory links between the units representing particular individuals. This model can account for a variety of repetition, semantic, and cross-modal priming data from familiarity and person-naming tasks, as well as some features of prosopagnosia (Carson & Burton, 2001).

This IAC model predicts how social information is processed for familiar individuals since PINs are the access points to pre-acquired information stored as one's social knowledge (Darling, Martin, & Macrae, 2010). However, it lacks the power to predict how information about strangers is processed. Furthermore, although this model predicts the interactions between face and NRUs on the identification level and SIUs on a conceptual level, it does not capture information on the scenario level (i.e., specific behaviours of the target person). Given the evidence from past research that STIs develop in childhood (Newman, 1991) and are largely automatic (McCarthy & Skowronski, 2011; Todorov & Uleman, 2002, 2004), it is natural to elaborate this IAC model with personality trait information units (TIUs) as a separate pool on the conceptual level, and behavioural information pools (BIPs) corresponding to different traits on a scenario level. See Figure 1.

In the current IAC model (Figure 1), each piece of behavioural information (e.g., 'wins research awards') clusters together with other behaviours, based on their common trait implications, to form pools of behavioural information (BIPs). Each BIP is linked to its corresponding TIU on the conceptual level and connects to the face and NRUs on the identification level through the PINs. Similar to the previous models, the bidirectional links between different behavioural information units within each BIP are inhibitory, whereas the links between behavioural information units and their corresponding trait units are excitatory.

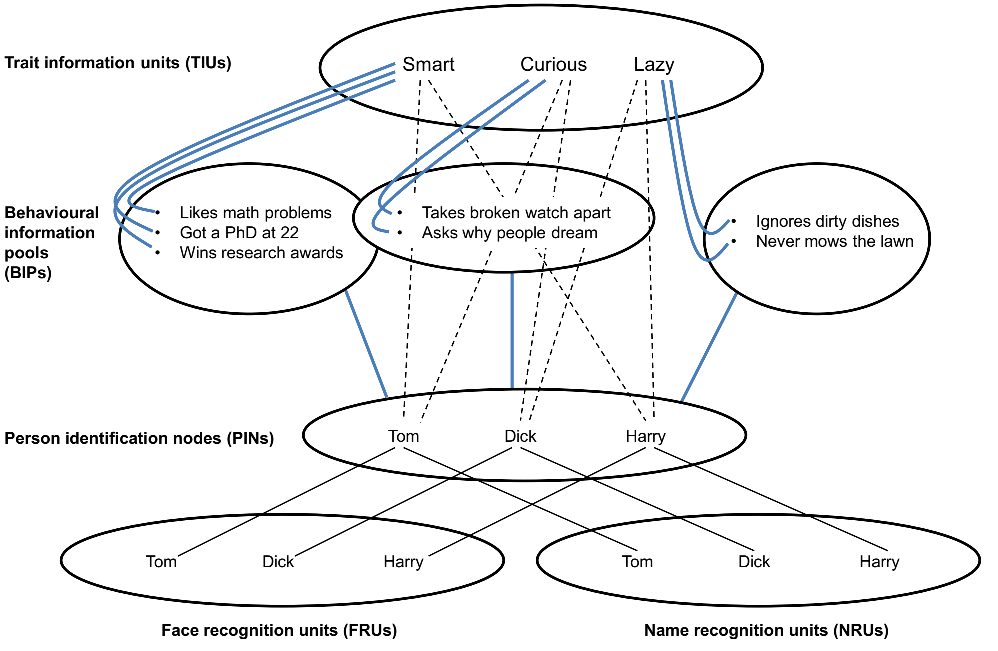

Figure 1. Central architecture of the IAC model of person perception for unfamiliar individuals. IAC, interactive activation and competition.

This organization of person knowledge goes beyond early classic research on the clustering of person knowledge in memory, because it includes face recognition and prior knowledge accessed through name and face cues. Hamilton, Katz, and Leirer (1980) pioneered this classic work by asking participants to either memorize entirely textual information about or form impressions of stimulus persons described by a series of trait-implying behaviours. Several behaviours implied each trait. Studies of clustering the behaviours in free recall showed clear evidence of clustering by trait implications. Although clustering was greater under impression formation than memorization instructions, it was significant in both cases. Hamilton, Driscoll, and Worth (1989) used clustering in free recall to show that trait incongruency and categorical complexity of behavioural information have complex effects on how person knowledge is organized in an impression formation task, thereby challenging the generality of previous simpler models.

Of course, many other variables can affect how person knowledge is organized in memory. For example, Hoffman, Mischel, and Mazze (1981) asked participants to sort the behaviours of target persons for various purposes. Targets' goals dominated the sorting when participants' purpose was to recall or empathize with the target, but traits dominated when their purpose was to form an impression or predict behaviour. Similarly, Ostrom, Pryor, and Simpson (1981) discussed how task variables, stimulus affordances, and prior person knowledge affect the organization of new person knowledge. They also demonstrated the operation of alternative organizational schemas for person knowledge, that is, organization in terms of times or places (e.g., what people did at the party last weekend) rather than persons (e.g., what John did).

In the present research, we began modestly by only presenting trait-implying behaviours organized by persons, and giving participants a memory goal. Although the resulting data cannot begin to address the full potential of the IAC model, we hope the results suggest the model's utility in predicting novel effects, and raise the possibility of relating other effects the model addresses to each other and to classic work in person memory.

Proactive interference and STIs

Proactive interference (PI) refers to the impairment in remembering a new item because similar items were learned previously (Keppel & Underwood, 1962; Underwood, 1969). It is thought to occur because every word or object we see or hear is encoded in terms of multiple categories, attributes, or psychological dimensions. Memorizing material from one specific category interferes with retention of new material encoded into the same category. Such interference can be avoided or released by introducing an item from a different category (hence, release from proactive interference, or RPI). For decades, research has suggested that PI and RPI are useful tools for investigating the categorical organization of semantic memory (e.g., Baddeley, 2012; Jonides *et al.*, 2008; Wickens, 1970).

Classic PI and RPI paradigms include the Brown–Peterson design (Brown, 1958; Peterson & Peterson, 1959), in which participants are presented with a particular type of material (e.g., trios of trees such as elm, oak, maple) across multiple trials. Each trial consists of a trio followed by a retention interval and recall test. With a series of trios from the same category, and a constant retention interval, recall performance declines across trials, suggesting a build-up of PI. Evidence for this build-up is apparent when, on a final critical trial, materials are presented from a different category, and memory performance is significantly better; that is, PI is 'released' (RPI). Such effects occur not only with words and numbers (Wickens, 1970; Wickens, Born, & Allen, 1963), but also with social materials such as names (Darling & Valentine, 2005) and faces (Darling *et al.*, 2010). The PI and RPI effects occur even when the categories are never made explicit.

If STIs occur online at encoding, behavioural information that implies the same trait category should create PI. Introducing behavioural descriptions that imply a different category should, conversely, release such interference.

STIs, the IAC model, and PI

Predictions of PI and RPI follow from the IAC model in Figure 1. Because multiple behavioural information units in a BIP are linked to the same TIU, presenting a piece of behavioural information activates that specific behavioural unit, which activates the corresponding TIU through an excitatory link, but inhibits other behavioural units in the same BIP through the inhibitory links (Read & Miller, 1998). Therefore, presenting multiple pieces of behavioural information from the same BIP should result in repeated inhibition of other behaviours in the BIP, producing PI. On the other hand, as the number of activated units in a single BIP increases, the more activated the corresponding trait unit becomes through the excitatory links. Consequently, the activated trait unit (the TIU) becomes a more accessible but a less effective cue for retrieving information from the BIP.

From a task performance perspective, the optimal strategy for free recall of behaviour lists (trios) is to not infer traits or use them as recall cues. Traits (or personality impressions) are never explicitly mentioned, so there is no instructional demand to infer traits. But avoiding trait activation becomes more and more difficult over trials because different behaviours repeatedly imply the same trait. Because participants presumably do not realize that they are inferring this same trait and that this behaviour categorization is producing memory decrements, they can hardly control it. So this activation of traits should produce PI. Once the category changes to another BIP, the units in the new BIP are less inhibited, and participants can more easily avoid traits as retrieval cues because the trait is not yet strongly activated. Therefore, RPI occurs.

Present studies

Two studies were designed to test the novel aspects of our IAC model, specifically the relations between and within the TIUs and BIPs. Using the interference effects noted above, support for the model would consist of decreased recall performance when behavioural sentences share the same trait theme (PI), which can be released by switching the implied trait on the critical last trial (RPI).

The major motivations for this inquiry are to suggest extending the McNeill and Burton (2002) IAC model to (1) knowledge of strangers, (2) at the scenario level, which includes information about (3) behaviours and (4) their trait implications. Towards these ends, we sought (5) to demonstrate PI and RPI effects with trait-implying behavioural information, which would provide novel evidence for the centrality of personality traits for spontaneously organizing person knowledge and (6) to expand the methods available for STI research by introducing PI and RPI as useful tools for probing the spontaneous structures of person knowledge.

In Experiment 1, participants read and memorized five trios of short behaviour descriptions that each implied the same trait. Each trio was performed by 'this person' and followed by a recall task. PI was expected to be evident in decreased performance over successive trials. After five trials, introducing a trio of descriptions implying a different trait with the opposite valence was expected to produce RPI, restoring memory performance on the sixth trio to the initial level. Experiment 2 explored whether RPI depends on switching both trait and valence, or whether new traits of the same valence would have the same effect. It also explored whether introducing, for each trio, multiple explicit NRUs – and the PINs they imply on the identification level – would have any effect. That is, would it matter if each behaviour in a trio was enacted by different named persons (e.g., Tom, Dick and Harry rather than 'this person' who did everything)? Note that in prior tests of the IAC model, the actors were known people with established identities rather than newly introduced and unelaborated names.

EXPERIMENT 1

Method

Participants

Participants were 156 undergraduates (126 females) from a Canadian university. Of these, 132 were in the introductory psychology subject pool and received partial credit for participating; 24 were not in the subject pool and had a 1/24 chance of winning a \$25 gift certificate for participating. Because the task involved English comprehension and the participants were required to type their responses, they were screened for English as their first language and for average or better typing skills.

Design

The experiment was a 3 (Condition: Control, PI, RPI) $\times$ 6 (Trials: T1, T2, T3, T4, T5, T6) factorial design, with repeated measures on the last factor. There were 53 participants in the control and PI conditions and 50 in the RPI condition. The condition variable was created through the composition of the behaviour lists presented. In the control condition, the behavioural trio on each trial implied a different trait, whereas in the PI condition, trios presented on all six trials shared a common trait theme. In the RPI condition, trios presented on the first five trials implied a common trait, but on the sixth trial, the trio implied a different trait. Within these design constraints on the trait implications of trios, behaviours making up each trio, and the order in which the trios appeared, were counterbalanced. The dependent variable was participants' performance on the free recall task, specifically the proportion of words correctly recalled on each trial.

Materials

To familiarize participants with the experimental task, a five-trial practice session took place before the experiment. Each practice trial consisted of three short behavioural sentences – a trio pertaining to an unnamed person, referred to as 'This person'. The behavioural sentences used for practice were vague in implying personality traits and shared no common trait theme. For example, one practice trio was 'This person . . . designs toy kites, hikes off-trail, has a green thumb'.

As in the practice session, in the experiment proper participants were presented with behaviour trios. The materials were 24 trios, comprising 72 behavioural sentences, each implying one of four personality traits – *Smart*, *Conscientious*, *Lazy*, and *Clumsy* – about a different unnamed actor. An example of an experimental trio is 'This person . . . knocks over ornaments, stubs big toe, bumps into people'. The next trio began with 'This person. . .' implying a different person.

Procedure

Participants were seated in a laboratory room and read instructions presented on a computer screen. They were told they would be asked to read and recall behaviours of fictional actors.

The participants then completed five practice trials followed by six experimental trials. Each trial consisted of three phases. First, the participant saw a fixation dot for 3 s, followed by a behavioural trio displayed at the centre of the screen for 5 s. Second, the participant completed a 10 s interference task, in which a random number between 200 and 900, not divisible by three, was presented. The participant was instructed to count aloud, backward by threes from the presented number. Third, the participant was given 20 s to recall the sentence trio and type it into three text fields in positions analogous to the trio presented initially. Speed and accuracy were emphasized in the task instructions. Participants were informed that neither sentence nor word order would affect their score. In the practice trials, participants were given feedback about the accuracy of recall and reminded of the importance of correct spelling. In the experimental trials, participants continued to the next trial without performance feedback until all trials were finished. The final practice trial was presented as the first 'experimental' trial, so that participants were not distracted by the transition from practice to experiment.

We used exact word recall for scoring trio memory results because (1) there were fewer than 20 words, and as few as nine in each trio; (2) more lenient criteria restricted variance and produced ceiling effects; (3) the short time (< 20 s) between trio study and test also restricted variance; (4) the most applicable gist criterion was often the implied trait itself; and (5) verbatim scoring was completely objective. For all these reasons, gist scoring was omitted.

Results

The primary data were the proportion of words correctly recalled from each trio.[1] The score was calculated by dividing the number of words correctly recalled by the total number of words in each trio. Because the interval between presentation and recall was so brief (10 s), only correctly spelled words counted; neither sentence nor word order affected the score.

Recall scores were examined in a 3 (Condition: Control, PI, RPI) × 6 (Trials: T1, T2, T3, T4, T5, T6) ANOVA, with repeated measures on the last factor (see Figure 2). The Trial × Condition interaction was significant, $F(2, 153) = 3.90$, $p < .02$, partial $\eta^2 = .049$, as were main effects for condition, $F(2, 153) = 5.61$, $p < .004$, partial $\eta^2 = .068$, and for trial, $F(1, 153) = 5.47, p < .02$, partial $\eta^2 = .035$. Recall in the control condition ($M = 0.47$, $SD = 0.23$) was higher ($p = .003$) than in the PI ($M = 0.38$, $SD = 0.25$) condition; recall in the RPI condition ($M = 0.42$, $SD = 0.26$) did not differ significantly from control or PI recall ($p = .22$ and .40, respectively).

The most important effect in the significant Trial × Condition interaction was a quadratic effect for trial in the RPI condition, $F(1, 49) = 7.41$ $p < .01$, partial $\eta^2 = .131$, with a slow decline in correct recall from Trial 1 through 5, then, as predicted, a full recovery on Trial 6. The decline of recall performance suggests an increase in PI over the first five trials followed by RPI on the sixth. In contrast, a significant negative linear trend was observed for trial in the PI condition, $F(1, 52) = 7.796, p < .01$, partial $\eta^2 = .13$; no significant effect for trial was found in the control condition. There were no differences between the PI and RPI conditions on Trials 1 through 5 (all $p = .43$–.95, $t = 0.06$–0.79, Cohen's $d = .01$–.05); however, recall was significantly better on Trial 6 in the RPI condition ($M = 0.48$, $SD = 0.21$) than in the PI condition ($M = 0.33$, $SD = 0.22$), $t(101) = 3.54, p = .006$, Cohen's $d = .69$).

The quadratic effect for trial in the RPI condition was further analysed by looking at each of the trait transitions separately: *Smart* trios in Trials 1–5 to a *Clumsy* trio in Trial 6, *Clumsy* in Trials 1–5 to a *Smart* trio in Trial 6, and, similarly, *Lazy* to *Conscientious* and *Conscientious* to *Lazy*. As shown in Figure 3, the pattern for *Lazy* to *Conscientious* differed from the other three. These materials showed only a linear effect for trial, $F(1, 11) = 6.402, p < .03$, partial $\eta^2 = .368$. All three others showed the significant quadratic effect.

Discussion

Experiment 1 provides evidence of PI when multiple lists of behavioural descriptions implying the same trait are memorized. It further suggests that RPI occurs when a new list of behaviours implying a different trait is introduced. It is surprising that such release is so thorough that recall on the last trial did not differ from the initial trial ($M_{\text{Trial 1}} = 0.47$, $M_{\text{Trial 6}} = 0.48$), $t(49) = 0.24$, $p = .80$, Cohen's $d = .04$. This result disconfirms an alternative explanation of the memory decline as being an effect of fatigue.

[1] *The phrase 'This person. . .' was not included in scoring recall of the trios.*

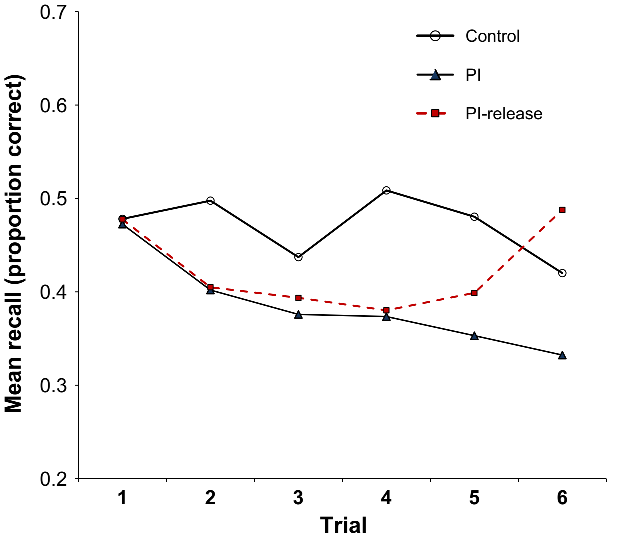

Figure 2. Mean recall as a function of trial for control, PI, and PI-release conditions in Experiment 1. PI, proactive interference.

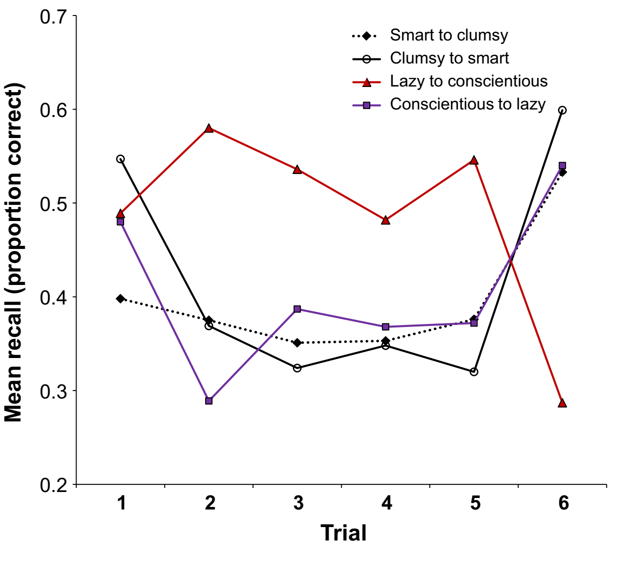

Figure 3. Mean recall scores in the PI-release condition in Experiment 1 as a function of trial and trait shift group: Smart to Clumsy, Clumsy to Smart, Lazy to Conscientious, and Conscientious to Lazy. PI, proactive interference.

Although an unexpected recall pattern was observed for the *Conscientious* to *Lazy* materials, no available data on these particular materials account for it. The three other RPI sets showed the predicted quadratic effect.

These results raise two issues that bear further examination. First, although the Brown–Peterson paradigm makes no explicit mention of our goal in the experiment (i.e., detecting STIs made from behaviours), it is possible that such a rich list of behaviour descriptions with trait themes created an implicit demand for participants to infer traits and form an impression of the actor in each trio (Park, 1989; Todorov & Uleman, 2002, 2004). Would these results still occur if the behaviours in each trio were attributed to different actors, thereby forestalling attempts to integrate them in single impressions? As described below, the IAC model also suggests that these effects may be weaker when behaviours are attributed to different actors.

Second, the recovery of recall performance on Trial 6 of the RPI condition may reflect a valence effect in PI. Because the valence of the trait implied in Trial 6 was opposite from the valence of the previous trait (e.g., *Smart* to *Clumsy*, *Lazy* to *Conscientious*), participants may have responded to the changed valence in addition to the changed trait category (Ferraro & King, 2004). Valence (evaluation) is implicitly inferred about others (e.g., Rydell, McConnell, Mackie, & Strain, 2006; Ybarra, 2002). It can also influence STIs (Carlston & Mae, 2007). Hence, we examined the extent to which the RPI effect is determined by a switch in valence in addition to switching trait category in Experiment 2.

EXPERIMENT 2

This study looked at effects on RPI of explicitly naming multiple actors for each trio, and of valence changes in addition to trait changes. We used a pretested sample of behaviour descriptions from the Experiment 1 traits and eight additional traits to replicate the findings of Experiment 1. In Experiment 2, the PI condition was dropped because both PI and RPI can be observed in the RPI condition. This left a two-level condition factor (control, RPI). In addition, subjects memorized 12 rather than six trios, to accommodate a within-subjects actor variable (same, different). In one set of trios, the three behaviours in each trio pertained to the same unknown actor ('This person. . .'), as in Experiment 1. In the other set, they pertained to three different, named actors. Whether 'same' or 'different' occurred first was counterbalanced between subjects.

According to the IAC model, each BIP is connected to the NRUs on the identification level. When we present only the behavioural information pertaining to 'this person', none of the units on the identification level is activated. However, if each behavioural information unit pertains to a different actor with an identifiable name, the actor's NRU gets activated upon acquiring the information, and through the excitatory link between the actor's name and the behaviour unit, the latter receives an activation that neutralizes some of the inhibition from other behavioural information units in the same BIP. As a result, we expected that PI and RPI would be weaker in the different-actor than in the same-actor condition.

In addition, Experiment 2 manipulated trio valence. In the control condition (in which each trio implies a different trait), the valence of the trios either alternated or was blocked such that the valence of the first three trios was the same and differed from the last three. This created a valence pattern factor (alternating vs. blocked) nested within the control condition. In addition, these series started with either positive or negative trios, counterbalanced between subjects. In the RPI condition (in which five behaviour trios implied the same trait and the sixth a different trait), the valence of the sixth trio was either the same as the first five (e.g., *Smart* [+] to *Honest* [+]), or different (e.g., *Smart* [+] to *Clumsy* [−]). This created a valence change factor (no vs. yes) nested within the RPI condition. In addition, these series also started with either positive or negative trios, counterbalanced between subjects. We hypothesized that a change in both the trait and valence might create a larger RPI than a change in only the trait.

Method

Participants

Eighty-five pretest participants (51 female) and 147 experimental participants contributed to Experiment 2. All were undergraduates from a psychology subject pool in a U.S. university and received partial course credit for participating. Three were dropped from Experiment 2 because they had no memory of sentences from more than two trios (actually from 7, 10, and 12 trios), leaving 144 (95 female). Participants were screened to be native English speakers, because English comprehension was central.

Design

The experiment was a 2 (Condition: Control, RPI) × 2 (Actor: Same, different) × 6 (Trials: T1, T2, T3, T4, T5, T6) factorial design, with the last two factors within subjects. In addition, the control condition included a nested valence pattern factor (alternating, blocked), and the RPI condition included a nested valence change factor (no, yes), both between subjects. The RPI condition contained one replication with different stimuli. There were also two counterbalanced between-subjects factors: Valence first (positive, negative) and actor first (same, different), each referring to characteristics of the trio presented first. As in Experiment 1, the dependent variable was the proportion of words in each trio (except actor names) recalled correctly.

Materials

The experimental materials were behavioural sentences that had been pretested on strength of trait implications. First, 14 personality traits and 310 characteristic behaviour descriptions were generated, half positive and half negative (Anderson, 1968): *Calm*, *Conscientious*, *Considerate*, *Curious*, *Friendly*, *Honest*, and *Smart*; and *Anxious*, *Clumsy*, *Insecure*, *Lazy*, *Selfish*, *Stingy*, and *Shy*. The behavioural descriptions, written to be diagnostic but bland, were presented to pretest participants in a questionnaire with the following instructions:

> For each sentence below, write down two personality traits or one-word descriptions that describe the person. You may use the same trait for several of the sentences. Then rate how vivid or memorable the sentence is to you on a 7-point scale (1: Not vivid at all to 7: Extremely vivid).

Three versions of the questionnaire were employed so that every sentence could be tested. Each questionnaire consisted of 120 items. Vividness ratings were tightly clustered around the scale midpoint, $M = 4.08$, $SD = 0.386$. The pretest eliminated *Friendly* and *Insecure* descriptions because trait consensuses were low. The remaining 156 behaviour descriptions implied 12 personality traits (see Appendix). Although behaviours for positive traits had more words ($M = 5.51$, $SD = 1.90$, range 2–10) than negative traits ($M = 4.60$, $SD = 1.58$, range 2–8; $t(154) = 3.25$, $p = .01$, Cohen's $d = .52$), this does not account for any valence differences obtained. Vividness scores were not analysed further.[2]

[2] *The vividness scores are available by contacting the first author.*

Note that PI should occur *on the basis of trait inferences* only if implied traits are the primary categories that unite behaviours within each triad. If other bases for categorization are also prominent, these could also produce PI but independently of trait inferences. Informal examination of the trios suggests some possibilities. Many trios implying *smart* involve reading, but this does not dominate any single trio. Trios implying *anxious* often involve worry, but this dominates only one such trio. And trios implying *lazy* frequently include inactions. Nevertheless, especially in the light of our pretesting materials for trait implications and the robustness of STI, we find it implausible (but not completely impossible) that non-trait categories may contribute to PI.

Procedure

As in Experiment 1, practice sessions preceded the experiment proper. Specifically, participants completed a five-trial practice session before the first experimental six-trial sequence, and a three-trial practice before the second experimental sequence. In the same-actor sequences, each trio was presented as pertaining to 'This person', as in Experiment 1. In the different-actor sequences, each sentence in each trio was presented as pertaining to a different named actor. For example, participants read, 'Tom sleeps in late, Dick does not look for jobs, Harry has breakfast delivered' (all implying *Lazy*). Other instructions and procedures were the same as in Experiment 1.

Results

The proportions of words correctly recalled from each trio were initially examined in a 2 (Condition: Control, RPI) $\times$ 2 (Actor: Same, different) $\times$ 6 (Trial: T1, T2, T3, T4, T5, T6) ANOVA, with repeated measures on the last two factors. The nested valence factors (valence pattern and valence change) were omitted in this initial analysis because their meanings differed by condition, and the two counterbalancing factors (valence first and actor first) were omitted for simplicity's sake.

The overall three-way interaction was not significant, $F(5, 710) = 1.03, p = .40$, partial $\eta^2 = .007$. But there were two main effects and a Condition $\times$ Trial interaction. Memory was better when the actor for the behaviours within trios was the same ($M = 0.58$, $SD = 0.24$) rather than different ($M = 0.52$, $SD = 0.25$), $F(1, 142) = 16.89$, $p < .0005$, partial $\eta^2 = .106$. Memory also differed over trials, $F(5, 710) = 4.57$, $p < .0005$, partial $\eta^2 = .031$, but this was qualified by the two-way interaction, $F(5, 710) = 10.40$, $p < .0005$, partial $\eta^2 = .068$. Relevant means are shown in Figure 4. They did not differ between conditions for the first three trials (all $p = .10$–$.96$, $t = 0.03$–1.68, Cohen's $d = .009$–$.28$). But on Trials 4, $t(142) = 4.50$, $p < .001$, Cohen's $d = .75$, and 5, $t(142) = 4.72$, $p < .001$, Cohen's $d = .79$, when PI was still increasing in the RPI condition, memory was poorer than in the control condition. Then on Trial 6, when RPI occurred in the RPI condition, memory was better in the RPI ($M = 0.60$, $SD = 0.23$) than in the control ($M = 0.52$, $SD = 0.26$) condition, $t(142) = -2.46$, $p = .015$, Cohen's $d = .41$.

Further analyses revealed the predicted quadratic effect for trial in the RPI condition, $F(1, 94) = 38.49, p < .0005$, partial $\eta^2 = .291$, with a slow decline in recall from Trial 1 through 5, followed by a full recovery on Trial 6 (Figure 4). (There were also significant uninterpretable higher-order polynomial effects, all $p = .000$–$.007$, partial $\eta^2 = .001$–$.075$.) In contrast and as predicted, the control condition showed neither

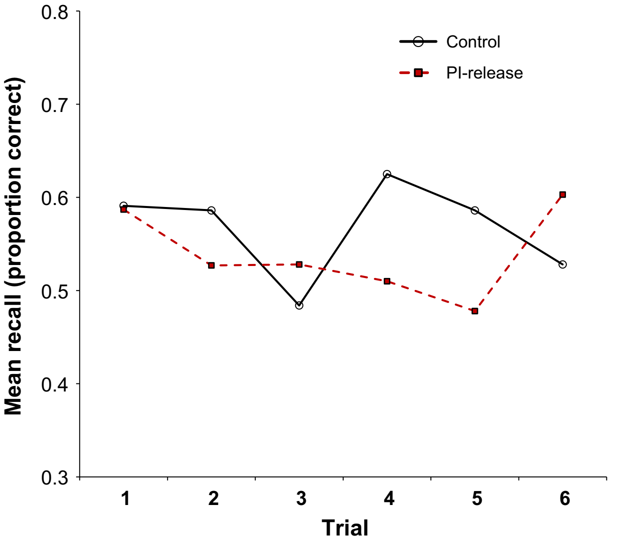

Figure 4. Mean recall as a function of trial for PI-release and control conditions in Experiment 2. PI, proactive interference.

a quadratic effect, $F(1, 48) = 0.38$, $p = .53$, partial $\eta^2 = .008$, nor a linear effect, $F(1, 48) = 0.72$, $p = .39$, partial $\eta^2 = .015$ (but only uninterpretable higher-order polynomial effects, $p = .000–.001$, partial $\eta^2 = .192–.294$).

Although the omnibus three-way interaction was not significant, our hypothesis – that PI and RPI would be weaker for different actors than the same actor – called for more focused analyses. For each of the first five trials, we compared recall in the control and RPI conditions, for same versus different actors. None of the interactions in these 2 × 2 ANOVAs approached significance, all $p = .15–.60$, $F(1, 142) = 0.27–2.09$, partial $\eta^2 = .002–.014$. In addition, on the possibility that same versus different-actor conditions would differ most clearly on the first six trials – before participants encounter the other condition on the second six trials in this within-subjects factor – we analysed only the first six trials. The Condition × Actor × Trial interaction was far from significance, $F(5, 705) = 0.79, p = .54$, partial $\eta^2 = .006$. None of the 2 × 2 ANOVAs reached significance either, all $p = .26–.99$, $F(1, 144) = 0.00–1.26$, partial $\eta^2 = .000–.009$. There was no support for our hypothesis.

In a secondary analysis bearing on valence change in the RPI condition, the nested valence factor (Valence Change: Yes vs. no) reflected whether or not the last PI-release trial involved a change in valence in addition to a change in the implied trait. Between subjects, the only significant effect was a main effect for which valence was first, $F(1, 87) = 5.20, p = .025$, partial $\eta^2 = .056$. Memory was better when the negative trios were first ($M = 0.568$, $SD = 0.23$) rather than second ($M = 0.510$, $SD = 0.24$). Because negative behaviours are generally more diagnostic than positive ones (Skowronski & Carlston, 1989), this suggests that starting with negative behaviours prompted deeper processing and more implicit rehearsal. There was also a marginal Trials × Valence Change interaction, $F(5, 435) = 2.22$, $p = .051$, partial $\eta^2 = .025$. However, it reflected irregular memory over the first five trials, and, contrary to a valence hypothesis, not a greater RPI when the valence as well as the trait implications of the behaviours changed on Trial 6. A 2 (Valence Change: Yes, no) $\times$ 2 (Trials: 1 through 5, 6) ANOVA showed no interaction, $F(1, 93) = 0.35, p = .55$, partial $\eta^2 = .004$. There were no other interactions with valence change, all $p = .17–.53$, $F(1, 87) = 0.33–1.87$, partial $\eta^2 = .004–.021$.

Thus, the data replicated the results of Experiment 1, consistent with a build-up and release of PI in the RPI condition but not in the control condition. However, there was no evidence of any effect of specifying the same versus different actors in each trio of behaviours. In summary, Experiment 2 replicated the PI and RPI effects of Experiment 1. Furthermore, secondary analyses indicated that valence had no effect: RPI was not increased by a change in valence, beyond that produced by a change in trait implication.

GENERAL DISCUSSION

Two experiments using different populations of subjects and materials showed that (1) PI occurs when behavioural descriptions implying the same trait are memorized, and (2) RPI occurs when behaviours implying a different trait are introduced. Consistent with prior research on PI and RPI (Baddeley, 2012; Jonides *et al.*, 2008), this provides a novel demonstration that behaviours can be spontaneously categorized in terms of their trait implications. Because these STIs occurred without any mention of traits or personality, and they interfered with memory performance, these effects provide further evidence that STIs are unintentional and uncontrolled. The results are robust. Besides replicating in two studies, Experiment 2 showed that they are unaffected by whether the behaviours are performed by the same or different actors. It also showed that RPI is similar whether the implied trait on the last trial is of the same or opposite valence.

Just as important, these results suggest that multiple STIs may be organized categorically, and these results are consistent with an extended interactive and competition (IAC) model of person knowledge. This extension (Figure 1) includes knowledge of strangers, at the scenario level incorporating behavioural and trait information. As such, it suggests a framework for integrating the extensive STI literature with the IAC literature on recognition of familiar people's names and faces (e.g., McNeill & Burton, 2002) as well as classic work on the organization of person knowledge in free recall (e.g., Hamilton *et al.*, 1989). Although the present studies only begin to test parts of this model, such an integration points to several directions for future research.

The IAC model and person perception

The IAC model (Figure 1) provides a ready explanation for the PI and RPI effects demonstrated here with STIs, just as it has for previous demonstrations of PI and RPI with faces of familiar people (Darling & Valentine, 2005; Darling *et al.*, 2010). It is striking that these two literatures – implicit social inferences (Uleman, Saribay, & Gonzalez, 2008), and the recognition of familiar faces – have developed with so little reference to each other. We hope this study will encourage the synthesis of these areas.

The fact that PI and RPI were not stronger when the behaviours in each trio referred to the same person rather than to different people merits further research with more distinctive and non-stranger PINs. In the IAC model, PINs are uniquely connected to various pools of information about familiar people, and pools of different sorts activate each other only through their connections with PINs. Our proposed extension of the IAC model assumes that this framework for storing information about familiar people is also used to accumulate information about novel people. But the two present studies were not designed to test this. We did learn that our manipulation of PINs in Experiment 2 ('Tom, Dick, and Harry' vs. 'this person') had no effect. Future research should use more vivid and differentiated instantiations of strangers, such as photographs with names. The extended model suggests that multiple vivid actors, each performing a trio of behaviours that imply the same trait, would produce less PI than the same single actor performing these behaviours, because the behaviours would be categorized by distinct actors rather than merely by their trait implications.

Finally, it must be noted that we have not implemented the full model computationally nor shown that this can be done, so we have not begun to tap its potential power. That goes well beyond the purposes of this initial demonstration of PI and RPI with STIs. But as our theories of person perception processes become more complex, computational models will become indispensible for seeing their implications. Even fairly simple models can have unexpected implications and provide new insights into familiar phenomena (e.g., Orghian, Garcia-Marques, Uleman, & Heinke, 2014).

STIs in the Brown–Peterson paradigm: Spontaneous encoding of behavioural information

We have argued that PI occurs when materials are encoded into the same category and that switching to a new category releases such interference. In Experiment 2, we controlled similarity in behaviours' theme, sentence length, valence, and vividness. Therefore, it is unlikely that PI and RPI resulted from participants' encoding behavioural information into categories other than traits. Thus, the present experiments provide new evidence for the old idea that personality traits provide organizing structures when memorizing other people's behaviour (e.g., Hastie & Kumar, 1979). Moreover, they indicate that the process occurs at information encoding, as PI is sensitive only to materials categorized at encoding.

An alternative explanation is that people strategically make trait inferences in recall tasks. According to this explanation, participants intentionally categorize behavioural descriptions into personality traits and recall them accordingly (Wyer & Srull, 1989). However, in a PI paradigm, this memorization strategy would be difficult given the number of items and limited time for memorization. Moreover, intentional categorization only makes the recall task more difficult as PI builds up, and thus, it is unlikely to be an activity participants deliberately engage in.

A second possible memorization strategy rests on using actors' identities to organize information and as retrieval cues. In the different-actor condition (Experiment 2), actors' names might have served as retrieval cues to reactivate the link with behaviours. However, this explanation predicts relatively stable recall over trials for behaviours performed by different actors. This did not occur.

Finally, one might wonder what evidence there is that these hypothesized implicit trait inferences are spontaneous. We can only observe that (1) there was no explicit mention of traits or impression formation in the instructions and that (2) making the STIs worked against optimal performance. Participants would have performed better if they had been aware of making STIs and had stopped doing so. For example, focusing on isolated elements of the behaviour descriptions, and treating the descriptions as unrelated words both reduce STIs (Uleman & Moskowitz, 1994). Participants did none of this. So all the evidence suggests STIs. Future research should test this more directly.

Future research directions

This research raises at least three fundamental questions about person perception and impression formation. All are old questions. But PI and RPI may provide new approaches, and our extended IAC model may have to be modified.

First, what are the factors that affect the centrality and importance of person identities in the organization of person information in memory? Experiment 2 provides a negative example: When identities are new (strangers) and relatively pallid, they are largely irrelevant. By contrast, the literature on recognition of familiar persons, from which we drew the IAC model, puts PINs at the centre of the model, largely on the basis of results from amodal semantic priming (e.g., Carson & Burton, 2001). An older literature on clustering of person information in free recall suggests person categories are important in the organization of information about strangers (Hamilton *et al.*, 1980, 1989; Sedikides & Ostrom, 1988, 1990). Clearly, there are multiple factors. Sedikides and Ostrom (1988, p. 263) list 'the structure of the stimulus field. . .exposure frequency. . .subjects' goals or processing objectives. . .subjects' pre-existing knowledge. . .the schematicity or redundancy of social information. . .and the social referent', each with research references. So future research must be alert to boundary conditions for the model being tested, and open to different models for different classes of conditions.

Second, what other *implicit* categories might operate in organizing person knowledge, and might these PI and RPI methods be useful in identifying the implicit use of particular categories? The present studies demonstrate that trait categories can be important, even when they are not explicit. Darling and Valentine (2005) showed RPI effects based on occupational categories, whether or not the categories were made explicit. They noted that 'this methodology has the potential to be used to investigate knowledge related to potent social categories, such as race, age, or sex' (p. 1008). And there is a long history of research on the use of implicit stereotype categories in memory, beginning at least with Taylor and Fiske's (1978) work on solo effects on memory for who said what in group discussions.

Third, how might PI and RPI be used to study downstream effects of the activation of implicit categories? For example, if initial behaviour trios activated a trait or stereotype that was applicable to, but ambiguously implied by, subsequent trios, would PI increase more over subsequent trios than if the stereotype had not been activated? And would subsequent trios confirm initial impressions, making it stronger or more resistant to change, reminiscent of Ross, Lepper, and Hubbard's (1975) perseverance effect (cf. Anderson, 1983)?

We look forward to further research on testing and extending the IAC model, to the development of PI and RPI as research tools for the study of implicit impressions and categorization, and to the integration of this work with that on familiar facial recognition.

Conclusion

Two experiments employed a classic memory paradigm to detect STIs. Reliable PI and RPI effects were found, showing that STIs occur online at encoding and that these trait categories can be used spontaneously to organize multiple pieces of such information. These effects are consistent with an extended version of the IAC model in which behaviours and personality trait categories (at the scenario level) play an important role in organizing person knowledge.

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Appendix : Examples of experimental trios in experiment 2

Calm		
Listens to the brook tumbling over rocks	Is good at controlling his anger	Fishes for hours
Conscientious		
Pays bills on time	Gets to work early	Keeps to study schedule
Considerate		
Waters neighbours' front yard when they are away	Whispers in library	Carries heavy items for the elderly
Curious		
Collects sea shells to study	Asks how swallows find their way	Observes earthworm movement
Honest		
Tells her friend that the pants do not fit	Tells the cashier she got too much change	Finally tells him about his bad breath
Smart		
Earned a PhD at 22	Reads ancient Greek	Publishes a poem in *The New Yorker*
Anxious		
Bites her nails	Weighs herself every day	Speaks too quickly in front of strangers
Clumsy		
Knocks over ornaments	Stubs big toe	Bumps into people
Lazy		
Skips classes	Does not exercise	Takes elevator one flight up
Selfish		
Does not give up seat to the elderly	Does not loan other campers his extra blanket	Picks out the best chocolates for himself
Shy		
Says nothing to the attractive girl	Feels uncomfortable with new people	Hopes others do not notice him
Stingy		
Never forgets a ten-dollar loan	Checks several gas stations for lowest price	Does not give to charity