**Article:**

Hutter, R.R., Allen, R.J. and Wood, C. (2015) The formation of novel social category conjunctions in working memory: A possible role for the episodic buffer? Memory. ISSN 0965-8211

https://doi.org/10.1080/09658211.2015.1020814

Hutter, R. R. C., Allen, R., & Wood, C. (2015 online). The Formation of Novel Social Category Conjunctions in Working Memory: A Possible Role for the Episodic Buffer? Memory

# The Formation of Novel Social Category Conjunctions in Working Memory: A Possible Role for the Episodic Buffer?

Abstract word count: 153

Main text word count: 8461

References word count: 1965

Notes word count: 129

No of Table: 0

No of Figures: 1

Keywords: WORKING MEMORY, BINDING, CATEGORY CONJUNCTION, IMPRESSION FORMATION

## Abstract

Recent research (e.g., Hutter, Crisp, Humphreys, Waters, & Moffit, 2009; Siebler, 2008) has confirmed that combining novel social categories involves two stages (e.g., Hampton, 1987; 1988; Hastie, Schroeder, & Weber, 1990). Furthermore, it is also evident that following stage 1 (constituent additivity), the second stage in these models involves cognitively effortful complex reasoning. However, while current theory and research has addressed how category conjunctions are initially represented to some degree, it is not clear precisely where we first combine or bind existing social constituent categories. For example, how and where do we compose and temporarily store a coherent representation of an individual who shares membership of ‘female’ and ‘blacksmith’ categories? In this article, we consider how the revised multi-component model of working memory (Baddeley, 2000) can assist in resolving the representational limitations in the extant two-stage theoretical models. This is a new approach to understanding how novel conjunctions form new bound ‘composite’ representations.

# The Formation of Novel Social Category Conjunctions in Working Memory: A Possible Role for the Episodic Buffer?

Thinking about conjunctions of social category memberships that are extremely unfamiliar or novel, for example a ‘female blacksmith’, requires the novel integration of information that may sometimes be conflicting or inconsistent (e.g., Roccas & Brewer, 2002)[1]. In this theoretical review, we aim to facilitate and stimulate future research, by discussing how information might be reconciled and impressions formed when thinking of category combinations that have not been previously encountered. Our goal is to achieve this with reference to recent theoretical and empirical developments both in the category conjunction literature and in working memory research. Specifically, our focus lies in an exploration of how the multi-component working memory model (Baddeley, 2000) can be applied to initial impressions formed through concurrent activation of multiple social categories.

Although two-stage models (e.g., Hampton 1987, 1988; Hastie, Schroeder, & Weber, 1990) of category combination offer an excellent framework with which to understand the stages involved in the combination process, they require further refinements. We will argue that the novel combination and manipulation of social categorical information structures stored in long term memory (LTM) can be understood in part as a process of binding that is driven by central executive resources and develops within the episodic buffer in Baddeley’s (2000) multi-component working model. It is assumed that the episodic buffer may bind or associate certain forms of information, resulting in integrated representational units (Baddeley, 2000). Our belief is that when a conjunction is novel (i.e. encountered for the first time), its constituents require binding within the episodic buffer to form a novel composite. When compatibility between the constituents in a novel conjunction is poor (i.e. poor compositional compatibility, see Groom, Sherman, Lu, Conrey, & Keijzer, 2005), then constituent binding should also be more effortful. This necessitates greater input from the central executive in the form of complex reasoning, with the online representation of the newly developed composite temporarily stored in the episodic buffer.

**Overview**

First, it is important to begin by defining social category conjunction. We delineate the range of types of social category conjunctions, by distinguishing between familiarity of the conjunction and congruity between the constituents. We will explore the representation of novel category conjunctions, to facilitate a greater understanding of their contents, before considering the processing of such conjunctions. This will include evidence for the resolution of categorical conflict in novel conjunctions through complex reasoning that draws on executive resources. Second, we evaluate the competing representational and processing models that apply to social category combination. Our aim is to shed light on the mechanisms involved in processing novel conjunctions, with the conclusion that two compositional compatibility approaches, namely Hampton's (1987; 1988) Composite Prototype Model and Hastie et al.'s (1990) two-stage model, most accurately model the processes involved. However, consideration of these models raises an issue not previously discussed in the literature that forms a central part of our argument – how and where might constituent information be bound and represented when forming novel conjunctions? We term this the composite representation temporary storage problem. Third therefore, we outline Baddeley's (2000) reformulated working memory model, with particular focus on the central executive and episodic buffer components, and the binding function attributed to these. This encompasses an exploration of binding information in working memory and the binding of LTM structures. We then propose that the composite storage problems inherent in Hampton and Hastie et al.'s models can be reconciled through the binding and storage functions of the episodic buffer component in Baddeley's revised working memory model. Fourth we outline a tentative model integrating elements of these theoretical approaches. We believe that this new model offers a solution to the composite representation temporary storage problem in social category conjunctions and also informs working memory research – where little has occurred in the way of investigating the binding of existing knowledge structures. Finally, we briefly discuss some further questions that might be addressed in future research.

**Defining Social Category Conjunction**

In line with previous work, we broadly define social category conjunction as a form of multiple categorization involving the concurrent activation and integration of two simple constituent categories to form a complex social category (Wood & Hutter, 2011). A number of approaches specifically extend the term to refer to conjunctions formed from correlated constituents (e.g., Crisp & Hewstone, 2007). Building on Crisp and Hewstone (2007) we define the term 'correlated' to denote the degree of compositional compatibility in the conjunction, based on the level of congruence in the relationship between the constituents. That is, positively correlated categories are highly congruent and compatible in conjunction whereas negatively correlated categories have low constituent congruence, and are perceived as having low compositional compatibility in conjunction. However, in line with a number of approaches in both social and non-social category conjunction research (e.g., Hampton, 1987; 1988; Wood & Hutter, 2011), we also include uncorrelated conjunctions (formed from the combination of unrelated constituent categories) within our definition of category conjunctions. Therefore, compatibility is our main interest in the present work, in particular for conjunctions that are novel. We focus entirely on encounters that are novel, that is when familiarity is at zero and constituent compatibility is the driving mechanism informing representational development (i.e. novel conjunctions). In these cases familiarity of the conjunction is of interest and not the constituent categories independently, or the familiarity of the head noun.

**Defining novel conjunctions**. There are distinct differences in the way perceivers form impressions of others when more than one categorical dimension is salient. Specifically, this is dependent on two dimensions: whether the conjunction is perceived to be familiar and whether it is congruent. To assist understanding of how these two dimensions interact, it is useful to partially outline an orthogonal crossing of these two dimensions. Perceptions of category conjunctions can be based on familiarity (familiar vs. relatively novel vs. novel) x congruency (congruent vs. unrelated vs. incongruent), resulting in nine conjunction types. However, for our purposes only novel conjunctions are relevant, because relatively novel and familiar conjunctions are readily represented in LTM, and thus are unlikely to require new binding following initial encounters and processing. In contrast, minimal pre-existing long-term knowledge is available for novel conjunctions, as these relate to a class of individual with whom the subject has had no prior contact. When crossed with congruence, this results in three possible conjunctions. For example, the conjunction ‘male blacksmith’ may be considered novel, given that the likelihood of having met a person sharing memberships of these categories is minimal. However, there is no inherent stereotypical incompatibility between the constituents that make up the conjunction. The conjunction ‘American blacksmith’, while also novel, is formed of constituent categories that have largely unrelated stereotypes. Accordingly, this is considered to be a novel-unrelated conjunction. Finally, a ‘female blacksmith’ can be considered novel-incongruent. Knowledge of females in this occupation is likely to be zero, making it a novel conjunction, and stereotypically female traits are not consistent with the occupational traits required of a blacksmith – that is, they are incongruent.

These examples clearly illustrate that extreme unfamiliarity can be crosscut by congruence and that the two are distinct concepts. In addition, the position a conjunction occupies on the broader familiarity x congruence dimensions outlined earlier has important implications for binding and impression formation. Groom et al. (2005) argue that when instances formed from earlier encounters (exemplars) are available in memory, familiarity drives impression formation. That is, representations formed by exemplars may be retrieved if conjunctions are still relatively novel. When numerous exemplars are available, making a conjunction familiar, representations are formed by an abstract summation of all the members of a given category (e.g., Brewer et al., 1981; Voorspoels, Vanpaemel, & Storms, 2008). This results in the formation of a prototype, and therefore prototypical representations apply when an encountered conjunction is familiar. However, this is not the case when existing conjunctive representations cannot be found; in this case compositional compatibility (i.e. congruence) becomes central to the representational and impression formation process in efforts to gain a clear coherent perception of novel conjunctions. It is this factor that is therefore most influential to the representation of novel conjunctions, which are the main focus of this review.

**The representational consequences of novel conjunctions**. Empirical research on impression formation of novel category conjunctions has demonstrated a relatively stable set of effects. First, encountering unfamiliar-incongruent social category conjunctions often leads perceivers to apply fewer (constituent) traits associated with the constituent categories independently when describing such conjunctions (e.g., Hutter & Crisp, 2005; 2006). Alternatively, relatively more new emergent attributes are used (cf. familiar-congruent conjunctions), that is, novel traits that are not used to describe the constituents (e.g., Hastie et al., 1990; Hutter, Crisp, Humphreys, Waters, & Moffit, 2009; Hutter, Wood, & Dodd, 2012; Kunda Miller, & Claire, 1990). While little or no research has focused on novel-congruent conjunctions or novel-unrelated conjunctions (as set out in our definitions outlined earlier), this suggests that impression construction draws on two components. First, schematic constituent stereotypic information stored in LTM is accessed and second, an alternative processes involving ad hoc combination leads to the application of non-stereotypic emergent attributes. However, these processes may be applied differentially dependent on the congruence of the unfamiliar conjunction encountered, and we discuss this further below. Through these processes, encountering novel category combinations can lead to the creation of new, complex categories (e.g., Barsalou, 1987; 1989; Brewer, Dull, & Lui, 1981; Stangor, Lynch, Duan, & Glass, 1992).

**Processing novel conjunctions.** What processes might be involved in building representations involving novel-incongruent conjunctions? Macrae, Bodenhausen, Schloerscheidt, and Milne (1999) have argued that when encoding counter-stereotypic information, a process of inconsistency resolution takes place, which requires executive cognitive resources (see also Hemsley & Marmurek, 1982). Macrae et al. (1999) observed that concurrent performance on an executive task impaired ability to process counter-stereotypical information. Although this research is not directly relevant to social category conjunctions, it suggests that inconsistency resolution, dependent on executive resources, would also be required to process extremely novel-incongruent conjunctions because these conjunctions are also non-stereotypic. This is in line with previous claims that conceptual combination formation is effortful rather than automatic (e.g., Hampton, 1997). Hutter and Crisp (2006), directly tested this possibility, finding that a concurrent number generation task resulted in a decrease in the generation of emergent attributes for novel-incongruent conjunctions, but not for attributes common to the constituents and combination (constituent attributes) – see also Hutter and Wood (in press). These findings suggest that cognitive effort is required only for certain aspects of combinatorial processing, while other aspects (the inheritance of constituent attributes in to the combination) remain automated.

Therefore, meeting a new individual who shares membership of conflicting categories can be cognitively effortful because they cannot be easily referenced with extant exemplars or prototypical social categories stored in LTM. This in turn means that undertaking other concurrent tasks (e.g., complex mental arithmetic) while forming an impression becomes troublesome, because greater resources (cf. congruent combination) have been allocated to the impression formation task.

When delineating novel-congruent or unrelated social category conjunctions however, our knowledge is less developed. Indeed, to our knowledge, impression formation of such conjunctions has never been directly examined empirically. The baseline comparison used in research on novel-incongruent conjunctions for example, is generally a familiar-congruent conjunction or a relatively novel-congruent conjunction. Accordingly, there is no objective evidence regarding the application of emergent and constituent features to novel-congruent or unrelated conjunctions, or the degree to which their novel representation is cognitively effortful. We therefore now turn to theoretical models that may offer an explanation as to how novel conjunctions are formed.

**Models of Category Conjunction**

The processes involved when engaged in gaining a coherent impression of novel conjunctions are unlikely to be sufficiently explicable by exemplar-based models involving access to information in LTM (e.g., Smith, 1990), because previous exemplars of novel conjunctions are by nature unavailable, having not yet been encountered. Indeed, the failure of exemplar models to explain novel conjunctions has been previously identified (e.g., Groom et al., 2005; Hampton, 1997; Rips, 1995). Likewise, prototypical processing, whereby a representation is formed through an abstract summary of all the members of a given category (e.g., Brewer et al., 1981; Voorspoels et al., 2008), also seems unlikely, again because in order to achieve this perceivers must have access to prototypes (i.e. stereotypes) in LTM that match the target's group membership. It can therefore be deduced that mechanisms based purely on existing LTM structures, whether they be exemplar or prototype-based by nature, are of limited use to perceivers in gaining coherence when confronted with novel conjunctions. Alternatively, a more useful approach might be to apply category coherence models, in which the constituents are combined actively and in an ad hoc manner, which is dependent on the type of judgment required in a given context (Groom et al., 2005).

Despite the developing empirical base on social category conjunctions, there are relatively few theories that explicitly model the cognitive processes involved in novel category combination, driven by category coherence, particularly with regards to emergent trait generation (see Crisp & Hewstone, 2007, for an account of the evaluative processes implicated in social category conjunction). The four accounts that do exist implicate varying mechanisms and stages. While Smith and DeCoster's (1998) connectionist account is based on parallel distributed processing (PDP) principles, Kunda et al.'s (1990) causal reasoning account, Hampton's (1987; 1988) Composite Prototype model and Hastie et al.'s (1990) two-stage model implicate more complex deliberative reasoning.[2]

Smith and DeCoster's (1998) Autoassociative Connectionist Model (ACM) explains the consequences of social category conjunction through connectionist principles (see also Van Overwalle, & Labiouse, 2004). Accordingly, it is argued that the emergent traits attributed to social category conjunctions are activated automatically, without recourse to effortful processes and in parallel, through spreading activation of traits associated with the constituents: That is, through activation of linked knowledge representations. It is clear however that a purely automatic mechanism is inconsistent with research demonstrating that emergent attribute generation in novel-incongruent conjunctions is attenuated by cognitive load (Hutter & Crisp, 2006; Hutter & Wood, in press). While it is plausible that emergent attributes may be activated via dual routes (both automatic and more effortful deliberative processes), emergent trait application in novel conjunctions cannot solely be the outcome of purely automatic processing. Furthermore, the connectionist approach is not consistent with evidence suggesting that the processing of novel-incongruent conjunctions involves two stages and is thus serial in nature (e.g., Hutter et al., 2009; Siebler, 2008).

In contrast to this connectionist approach, Kunda et al. (1990) identify deliberative reasoning as the mechanism behind processing of social category conjunctions. They propose that the discord inherent in surprising conjunctions (consistent with our concept of novel-incongruent conjunctions) in particular triggers causal reasoning, a conscious and purposeful process of inconsistency resolution that draws on knowledge within and outside the constituent categories. Kunda et al. argue that emergent traits are the result of this causal reasoning, reflecting an attempt to resolve the conflicting information obtained from the constituent categories. While this proposal is consistent with the research on cognitive load outlined above because it is cognitively effortful, Kunda et al.'s account appears not to fully explain the processing of novel-congruent or unrelated conjunctions, only briefly discussing that ‘unsurprising’ conjunctions are less likely to involve casual reasoning. Perhaps more importantly, this model also implies that causal reasoning is immediately instigated, which is not consistent with recent empirical findings (e.g., Hutter et al., 2009; Siebler, 2008).

Hutter et al. (2009) for example, found evidence instead suggesting that impression formation of conjunctions follows a two-stage pattern. Both incongruent and congruent category conjunctions were characterized by greater application of constituent over emergent traits in the initial stages of impression formation. However, in the later stages of processing, only congruent category conjunctions continued to show this pattern, with incongruent category conjunctions instead prompting disproportionately greater relative application of emergent traits. These findings suggest that while constituent traits are first applied to conjunctions, the catalyst resulting in emergent trait generation (e.g., causal reasoning) occurs later during the impression formation time course.

Further evidence for dual processes comes from Siebler (2008), who had participants rate attribute typicality for constituent categories. Next, a comparison was drawn with ratings using the same attributes when made for the conjunctions formed through the same constituents. Attributes rated one scale point below or above that allocated to the constituents were considered emergent. Results confirmed that more emergent traits were applied to incongruent versus congruent conjunctions, in accord with both Kunda et al. (1990) and Hastie et al. (1990). Response latencies were also recorded revealing that longer latencies were associated with incongruent conjunctions only, again supporting Kunda et al. However, longer response latencies affected first ratings disproportionately – an effect inconsistent with Kunda et al.’s model, which predicts a unified impression that is immediate (i.e. no activation of discrete stages).

**Two-stage accounts: Hampton (1987; 1988) and Hastie et al. (1990).** Like Kunda et al.'s (1990) account, both Hampton (1987; 1988) and Hastie et al. (1990) implicate more effortful reasoning processes in the application of emergent trait generation in social category conjunctions, and so are able to capture aspects of Siebler's (2008) findings. However, in contrast to Kunda et al.'s approach, both present a two-stage account of the processes involved, and thus provide a better fit for the results reported by Siebler (2008) and Hutter et al. (2009).[3]

Hastie et al. (1990), for example, argue that deliberative complex reasoning is triggered only after initial simple processing fails (cf. Kunda et al., 1990). During the first stage of impression formation, information from the constituent categories is averaged or added in a manner consistent with existing theories (e.g., theories on averaging; Anderson, 1981). This may be sufficient to form a coherent representation of both novel-congruent and novel-unrelated conjunctions. However, if this process fails to result in a coherent impression, as is particularly likely with novel-incongruent conjunctions, a second stage of complex reasoning is instigated. Hastie and colleagues suggest three complex reasoning strategies that may be used to resolve discrepancies, with perceivers searching memory for similar but crucially not identical previous encounters or 'analogues', referring back to general knowledge and rules, or engaging in mental simulations.

While less expansive on the mechanisms involved in emergent trait generation at stage 2, Hampton's Composite Prototype Model also presents a similar account of category conjunction. Like Hastie et al.'s (1990) model, recent refinements of the composite prototype model argue that processing of category conjunctions follows two stages (Hampton, Dillane, Oren, & Worgan, 2011). In the first stage, constituent traits are combined to form a composite using a weighted average, following the compilation of a single list of attributes from each constituent.

Greater typicality and centrally important features when in constituent form also predict typicality and centrality for the conjunction. This stage may be sufficient to form a coherent representation for both novel-congruent and novel-unrelated conjunctions. A second stage is activated to restrict traits from the constituents that conflict with one another and therefore are impossible when in conjunction, and to facilitate (inherited) traits that are necessary (to the constituents) into the conjunction. Hampton (1988) provides a useful example of these second stage processes in operation through the conjunction ‘Pet fish’. Pets (through necessity) ‘have owners’, however, some pet attributes (e.g., ‘warm and cuddly’) are not possible for the constituent fish. Pet fish as a result inherits ‘have owners’ but not the impossibilities ‘warm and cuddly’. Similar to Hastie et al.’s model, the second stage of processing facilitates coherence, in which background theoretical knowledge is used to resolve any conflict. It is this stage that may result in the application of emergent traits, and is particularly likely in novel-incongruent conjunctions, for which conflict between constituents is inherent.

It is clear that both Hampton’s (1987; 1988) Composite Prototype Model and Hastie et al.’s (1990) two-stage model implicating complex reasoning provide the most complete explanation for impression formation of novel conjunctions to date. As discussed earlier, recent evidence has shown that processing does follow a two-stage pattern (e.g., Hutter et al., 2009; Siebler, 2008). In addition, the likely effortful nature of a complex or theory-based reasoning mechanism fits well with research suggesting that emergent attribute generation in novel-incongruent conjunctions is attenuated by cognitive load (Hutter & Crisp, 2006; Hutter & Wood, in press). Both theories adequately model the processes involved in all types of novel conjunctions (i.e. incongruent, congruent and unrelated conjunctions), though Hampton’s (1987; 1988) model is more detailed in accounting for stage one processes and Hastie et al.’s (1990) at stage two. However, in each case, the formation and early representation of novel composites is likely to require temporary storage space in which such representations are constructed, an issue that is not fully addressed in these, or any other existing models of representation or impression formation.

**The composite representation temporary storage problem.** Previously encountered exemplar composite categories already exist in memory based on previous interactions, and these composites are relatively common (Groom et al., 2005). When exemplars become numerous, impressions would be expected to move from this form of representation to abstract, prototypical representations based on averaging members of a category (e.g., Brewer et al., 1981; Voorspoels et al., 2008), or in this case, averaging members of a category conjunction.[4]

Less clear however, is how these conjunctions are first composed when categories are novel, requiring the creation of new composite representations that are then allocated to LTM. While research has shown that effortful processing in the form of complex reasoning is necessary when novel-incongruent conjunctions are first encountered (Hastie et al., 1990; Hutter & Crisp, 2006; Kunda, et al., 1990), other aspects of the process are poorly understood. In particular, how is information involving multiple categories first 'bound' together to form coherent representations in memory? Does this differ depending on the congruence of the conjunction? Where might it be temporarily stored during binding? If, as previous research suggests, complex reasoning processes are involved in the formation of novel representations of novel-incongruent conjunctions (e.g., Hastie et al., 1990; Kunda et al., 1990), this requires a 'mental workspace' in which to construct such representations. It is clear that it is not sufficient to note only that attentional resources are important in drawing on and integrating information from LTM in novel ways (e.g., Hutter & Crisp., 2006; Hutter & Wood, in press). We also need to outline how information is temporarily retained and manipulated during and after this construction process. In short, where does this process develop? We next outline Baddeley's (2000) multi-component model of working memory before suggesting that requisite working memory components and processes may be directly involved in the 'binding' of novel conjunctions.

**The Multi-Component Model of Working Memory (Baddeley, 2000)**

Working memory can be viewed as a temporary storage and processing system, providing the capacity to briefly maintain, manipulate, and utilize information (Baddeley, 2007). It sits at the heart of cognitive functioning, serving as a workspace for temporarily retaining and manipulating the results of perceptual processing and information stored in LTM. Furthermore, measures of working memory consistently predict performance on a range of tasks, including complex reasoning, decision-making, academic development, and general intelligence (Daneman & Carpenter, 1980; Engle & Kane, 2004; Kyllonen & Christal, 1990). A particularly influential theoretical approach to working memory is the model originally proposed by Baddeley and Hitch (1974; Baddeley, 1986), comprised of multiple temporary storage and processing components that are distinct from long-term memory systems. This model constituted an attentional control system, the 'central executive', and two sub-systems, the 'phonological loop' (for holding auditory-verbal information) and the 'visuospatial sketchpad' (for visual and spatial information). The potential role of executive resources in driving complex reasoning and resolving incongruent conjunctional elements has already been noted, and will be discussed further in the context of a model aimed at capturing such processes. Potential contributions from verbal and visuospatial components of working memory do not form a main focus of the current approach, though are considered in the final section.

More recently, Baddeley (2000) added a fourth component, the episodic buffer. This was described as a limited capacity, modality-independent store serving as an interface between the sub-systems, the central executive, and LTM. Crucially, it was assumed to be capable of binding and integrating new information from different sources, including from the other sub-systems of working memory and from LTM, thus serving as a temporary storage system during and following binding. This new component was added not least because some data did not fit with predictions leading from the original model. For example, it is possible to temporarily store representations of meaningful sentences of +15 words (e.g., Baddeley, Hitch, & Allen, 2009; Baddeley, Vallar, & Wilson. 1987), even though this greatly exceeds phonological loop capacity. In addition, the three-component model (Baddeley & Hitch, 1974; Baddeley, 1986) provided no explanation for how information from different sources could be integrated in working memory (e.g., Allen, Baddeley, & Hitch, 2006; Allen, Hitch, & Baddeley, 2009; Darling, Allen, Havelka, Campbell, & Rattray, 2012; Elsley & Parmentier, 2009). Of particular relevance to the present discussion was the suggestion that the episodic buffer is central to manipulating and recombining information held in LTM (Baddeley, 2000).

**Binding information in working memory.** Initial exploration of the episodic buffer concept has focused on its involvement in the binding of features into integrated episodes or chunks in working memory, with particular emphasis on the role of the central executive in this process (see Baddeley, Allen, & Hitch, 2011; Nobre et al., 2013). This was motivated by the original assumption that executive control is crucial for the creation of new bound representations, with access to the episodic buffer always proceeding via the central executive (Baddeley, 2000). However, work in the visuo-spatial domain examining the binding of simple features such as color and shape into unitized representations (Allen, et al., 2006; Allen, Baddeley, & Hitch, 2014; Allen, Hitch, Mate, & Baddeley, 2012) has indicated that such integrative processes may in fact develop relatively automatically, with conditions requiring memory for shape-color conjunctions (e.g., red-circle) generally no more affected by the concurrent performance of an executive task than conditions simply assessing memory for constituent features. Similarly, examination of the processes supporting the chunking of linguistic sequences in working memory also suggests that the central executive is less important in such processes than originally assumed (Baddeley et al., 2009; Berlingeri et al., 2008; Gooding, Isaac, & Mayes, 2005). Therefore, at least for the forms of binding investigated in these studies, it may be more appropriate to view the episodic buffer as a passive recipient of bound representations that are automatically created via other cognitive processes (Baddeley, Allen, & Hitch, 2010; 2011). Thus, the buffer may function as the basis for conscious awareness of bound information created elsewhere in the cognitive system.

In contrast, it is possible that these automatic processes become insufficient for other types of binding, and executive control resources are then required. Indeed, distinctions have been suggested between different forms of binding, with associated variations in the cognitive mechanisms and neural areas that may contribute (e.g. Zimmer, Mecklinger, & Lindenberger, 2006). One broad set of distinctions that has been drawn in the literature (e.g. Ecker, Maybery, & Zimmer, 2013; Parra, Fabi, Luzzi, Cubelli, Hernandez Valdez, & Della Sala, 2013) is that between ‘conjunctive’ or ‘intrinsic’ binding on the one hand (i.e. for information that belongs to the same perceptual unit, such as the shape and colour of an object), and ‘relational’ or ‘extrinsic’ binding on the other (i.e. when to-be-bound information is distinct and/or contextual in nature). This latter category of binding might include integration of information separated in space (e.g. Delvenne & Bruyer, 2004; Ecker et al., 2013; Karlsen, Allen, Baddeley, & Hitch, 2010; Parra et al., 2013), by domain (e.g. verbal and spatial; Elsley & Parmentier, 2009; Langerock, Vergauwe, & Barrouillet, 2014; Morey, 2009), and by modality (e.g. auditory and visual; Allen, Hitch, & Baddeley, 2009; Maybery et al., 2009; Wang, Allen, Lee, & Hsieh, in press). The extent to which binding in these circumstances might particularly load on executive processes is as yet unclear though; few studies have directly explored this question through dual task manipulations, with a mixed picture of findings emerging from those that have done so (Allen et al., 2009; Elsley & Parmentier, 2009; Karlsen et al., 2010; Godoy & Galera, 2011; Langerock et al., 2014). Thus, further work will be needed to address this broad and important question, but it is certainly possible that some forms of more complex or disparate binding can only be achieved via focused attention and active construction within the episodic buffer.

**Binding long-term memory structures.** One important potential role of the episodic buffer that remains underexplored relates to how working memory interacts with LTM, and in particular how it may be involved in the retrieval, manipulation, and recombination of different knowledge structures that are already based in LTM. The episodic buffer is claimed to be the principal link between working memory and LTM (Baddeley, 2007). Furthermore, one of the capacities originally attributed to the episodic buffer was that of novel manipulation of pre-existing knowledge, leading to the construction of new bound ‘composite’ representations. Baddeley (2000) discusses the example of an ‘ice-hockey playing elephant’, and notes “This would raise the question of how he would hold the stick, and what would be his best position; he could no doubt deliver a formidable body check, but might be even better in goal” (p.420). This process of creating and manipulating mental models from LTM through binding is assumed to be an active function of the episodic buffer (Baddeley, 2000), with this level of binding potentially drawing heavily on central executive resources, in contrast to other, more automatized forms of integrative processing (Baddeley et al., 2011).

In terms of application, this potentially speaks significantly to research in social cognition on the processes and representational consequences of encountering novel-conjunctions (e.g., Hastie et al., 1990; Hutter & Crisp, 2005; 2006; Hutter et al., 2009; Kunda et al., 1990). We will now consider how Hampton's  (1987; 1988) Composite Prototype model and Hastie et al.'s two-stage model may be usefully integrated with working memory theory in gaining a clearer picture of social category processing.

**Binding social categories: Resolving the composite representation temporary storage problem.** It is logical to assume that the reference to background theory implicated in the second stage of Hampton's model (e.g., Hampton et al., 2011), and the complex reasoning (including problem-solving and mental simulation) processes similarly described within the second stage of Hastie et al.'s (1990) model, develop within working memory, a system central to complex reasoning and problem solving (e.g., Baddeley & Hitch, 1974; Kyllonen & Christal, 1990). In particular, it has been claimed that novel conjunctive social categories are represented and formed using central executive resources (e.g., Hutter & Crisp, 2006; Hutter & Wood, in press). However, such conclusions require further exploration in light of the amended working memory model (Baddeley, 2000). As noted above, the question arises as to where in working memory new conjunctions are generated and temporarily stored. The assumption that this ability relies solely on central executive processing is problematic given that the executive is not assumed to have storage capacity (Baddeley & Logie, 1999). It is also difficult to see how existing 'crystallized' knowledge structures within LTM itself might be flexibly manipulated and recombined, especially when constituent elements are incongruent when in conjunction, thus rendering automatic 'averaging' prototypical processes (e.g., Anderson, 1981; Smith, Osherson, Rips, & Keane, 1988) ineffective. Similarly, the same applies to exemplar-based processing because, by definition, exemplars do not exist in LTM for novel-incongruent conjunctions.

The revised working memory model (Baddeley, 2000) when applied to models based on compositional compatibility (i.e. Hampton, 1987; 1988; Hastie et al., 1990) therefore offers the opportunity to reassess and extend previous findings, and develop a clarified and modified understanding of the processes involved in novel conjunctive category formation. This also allows a test of a number of new predictions based on the premise that the processes of initially building and representing a conjunctive category formed from two constituents may in fact be better expressed as a function of binding within the episodic buffer.

**The Revised Novel Conjunctive Compatibility Two-Stage Model**

The refinements in Baddeley's (2000) working memory model allow us to address and clarify how composite categories formed using complex reasoning are represented and temporarily stored. A schematic diagram illustrating an integration of elements of the Hampton (1987; 1988)/Hastie et al. (1990) and Baddeley (2000) theoretical approaches is set out in Figure 1. It is prudent to refer here in particular to Hampton's et al.'s (1987; 1988) model because this best encapsulates stage one processes (outlined earlier) involved in some compatibility models.

During an initial stage of processing, if a conjunction has been previously encountered, the relevant representation will simply be recalled from LTM as a pre-bound conjunction (see Figure 1, a). In contrast, novel conjunctions will require initial links to be formed between constituent elements. Therefore, representations of each constituent category are retrieved from LTM (as illustrated by the double arrows in Figure 1, b and c). For novel-congruent conjunctions and novel-unrelated conjunctions (Figure 1, b), we suggest that constituents are bound into initial composite representations through addition and averaging processes. The representation is temporarily stored in the episodic buffer during and following this process. However, positive or zero correlations amongst traits originating with the constituents mean that complex recalculations using causal processes are unnecessary and so second stage processing remains inactive. Therefore, while we suggest that processing of new unrelated or congruent conjunctions still comes with a small cost to executive-based processing resources, this is not as a result of complex reasoning, and is therefore reduced in magnitude relative to incongruent conjunctions (see below).

It is important to note here that while we predict a similar pattern for both novel-congruent conjunctions and novel-unrelated conjunctions, emergent features have often been observed for unrelated conjunctions. However, activation of emergent attributes for this conjunction type is seemingly dependent on earlier encounters and stored exemplars (i.e. extensional information; Hampton, 1997a). Extensional information in the form of conjunctions cannot be accessed in the case of novel-unrelated conjunctions – it simply does not exist in LTM. Therefore two things follow: a) When encountering novel-unrelated conjunctions, perceivers will not activate emergent attributes, with primarily only adding or averaging processes developing instead; b) When emergent attributes have been observed for unrelated conjunctions previously it is via extensional knowledge and as such these emergent attributes are unlikely to have been generated through stage 2 causal processes.

Figure 1 about here

However, these processes are insufficient for the formation of a coherent impression when novel-incongruent constituents are encountered in conjunction, due to unresolved impossibilities, the inclusion of necessities and activation of background theories and real world knowlege. In this case, we suggest that stored LTM prototypical structures regarding the constituent elements are retrieved (in accord with Hastie et al., 1990 and Hampton, 1987; 1988), and temporarily stored in the episodic buffer (Figure 1, c). At this point, much like the novel-congruent conjunctions and novel-unrelated conjunctions discussed earlier, stage one processes are activated which can be additive (Hastie et al., 1990) or reliant on weighted averaging (Hampton, 1987; 1988; Hastie et al., 1990). This process terminates when the system reaches the point where all the attributes that it is possible to add or average is complete, leaving only attributes that are inconsistent with one another across the constituents in the combination.

In our revised model, the episodic buffer then serves as the cognitive workspace during active, on line construction of novel conjunctions (see stage 2 of Figure 1), a process involving complex reasoning that draws particularly heavily on effortful central executive processing. As outlined earlier, this involves the complex reasoning stage (stage 2) of Hastie et al.'s (1990) model, or theory-based reasoning (a second stage in Hampton et al., 1987; 1988). According to Hastie et al.'s model, three strategies are possible: a memory search for previously encountered analogues; the implementation of general knowledge in conjunction with reasoning; or, processes of mental simulation. We argue here that the use of all of these strategies in the formation and binding of a composite representation develops within the episodic buffer component of working memory, driven both by central executive support and ongoing retrieval of related information from LTM. For example, in restricting impossible traits and including necessary traits from the constituents into the conjunction, the formation of coherence is facilitated. This involves the recalculation of the correlations amongst traits with reference to background theoretical knowledge, therefore leading to conflict resolution. The end product of processing in stage 2 is the formation of a new bound composite representation, including the development of novel emergent attributes (e.g., Hastie et al., 1990; Hutter et al., 2009), which can serve as the basis for impression formation, and may subsequently be consolidated into LTM.

It is useful to note that the broad distinctions we outline here between different forms of conjunction formation, and the predicted variations in executive load and the need for active binding within the episodic buffer associated with each of these, may to some extent map onto distinctions that have been suggested between other forms of binding process (e.g. Ecker et al., 2013; Parra et al., 2013; Zimmer et al., 2006). Thus, the integration of elements for different types of social category conjunction might represent one example of a wider set of differences between automatic and more effortful binding processes. This may be an informative perspective to retain in future work aimed at further tying together experimental and theoretical developments in working memory and social cognition. We might tentatively speculate, for example, that novel-incongruent conjunctions place a greater reliance on effortful binding, while novel-congruent conjunctions primarily involve automatic binding.

It is also worthwhile considering where, if not in working memory, Stage 2 bound representations and coherence checking might occur. Earlier we briefly discussed connectionist models of category conjunction (e.g., Smith & DeCoster's, 1998 ACM), according to which effortful inconsistency resolution is unnecessary and trait conflicts resolved automatically. Therefore, theoretically Stage 2 processing (or to be precise activation of knowledge representations) could occur outside of working memory under this approach. As outlined previously however, effortful processing seems to be a requirement when real participants are faced with novel-incongruent conjunctions in experimental settings (Hutter & Crisp, 2006; Hutter & Wood, in press). Therefore, evidence suggests that these processes are under conscious control and take place within working memory; we would suggest that the Baddeley multicomponent working memory model provides the most suitable framework within which to consider these processes.

**Further Questions**

Our aim at this stage is to present a novel integration of existing theoretical work from distinct areas of research, with the intention of bridging the gap between working memory and social cognition, thereby developing understanding of the processes under discussion and stimulating further empirical exploration. Our proposed framework provides a set of clear predictions regarding the involvement of executive processes in different forms of conjunctive processing. In addition, there is a range of further issues that could be addressed if this direction is to prove fruitful.

While Hampton’s (1987; 1988) Composite Prototype Model and Hastie et al.’s (1990) two stage model currently provide the best models of how perceivers form impressions using novel category conjunctions, and account for more empirical findings than competing models, they do have some limitations and aspects that are either less well-defined or in need of further testing. For instance, Hastie et al. identified different forms of complex reasoning based on participants’ reporting of strategy use. It would be important to carefully examine the kinds of reasoning that may be involved across different categories and contexts. For example, there may be variability in the frequency and productivity of different forms of reasoning, and the relative demands they place on executive resources.

A number of unanswered questions exist regarding the precise operation of memory components in category combination and impression formation. One issue concerns the retention of multiple newly bound conjunctions. Cowan (2001) suggested a working memory capacity limit of around four ‘chunks’ of information, a limit which is likely to be applicable to the episodic buffer (Baddeley, 2007). This raises the question of whether multiple conjunctions can be built and temporarily retained in working memory, and whether capacity is limited by number of conjunctions, amount of detail related to each conjunction, and/or the type of conjunction (e.g., novel-incongruent) that is involved. If more than one newly integrated category conjunction is retained in working memory, this might be expected to lead to occasional ‘illusory conjunctions’, analogous to those seen in visual search and short-term memory (Treisman & Gelade, 1980), in which attributes or even whole categories become falsely combined. For example, as red triangle and blue circle may inappropriately become red circle in visual perception and working memory, so too might the attributes or constituents of newly formed conjunctions become confused and recombined in memory. Furthermore, variation may emerge in the likelihood with which newly formed conjunctions fall apart into their constituent features and then incorrectly recombine, as a function of conjunction type. Careful investigation is required to identify the different forms of error that may be generated, and the conditions under which these errors vary in frequency. Although forming impressions of simultaneous conjunctions is not a well-developed area in social cognition, perception under these conditions is not unprecedented in everyday life. For example, moving to a new workplace for, or when on international travel may lead us to encounter a number of new and old category conjunctions in parallel. It would be a worthwhile endeavor to study how our cognitive systems manage these types of very taxing impression formation scenarios.

We have suggested central executive resources to be particularly important for the initial formation of certain types of category conjunction. It remains to be seen whether this is also important in retaining such representations over brief periods of time. Recent work has demonstrated that attention-demanding concurrent tasks performed during encoding of visual object sequences particularly impacts on memory for the earlier items in the sequence (Allen et al., 2014). Similarly, strategically directing focused attention to the earlier items in a sequence boosts their subsequent recall (Hu, Hitch, Baddeley, Zhang, & Allen, 2014). These outcomes have been interpreted as reflecting the importance of focused attention in holding representations in an accessible, privileged state, possibly within the episodic buffer (Hu et al., 2014). It would be worthwhile to explore whether the control of focused attention operates in the same way for maintenance of novel category conjunctions, and how the requirement to form new incongruent conjunctions (proposed to be an effortful process) impacts on retention of items already held in memory. It would also be of interest to examine whether the apparent susceptibility of bound representations to environmental interference (Ueno, Allen, Baddeley, Hitch, & Saito, 2011) also extends to category conjunction retention. Exploring these questions would provide tests of whether the possible constraints on episodic buffer functioning (identified in research on visual feature binding) also apply to this very different form of conjunctive processing.

A further issue of interest concerns the role of other processing and storage sub-components within working memory. In the current outline, we suggest that the central executive provides important processing power to support complex reasoning (Hutter & Crisp, 2006; Hutter & Wood, in press), and that this process of active conjunction construction develops within the episodic buffer. However, little is known about how visuo-spatial and phonological processing may also contribute. For example, Quinn and McConnell (1996) examined the impact of different forms of irrelevant stimuli on the creation of novel integrative visual images, and found evidence for separable contributions from both visual working memory and executive resources. Similarly, Baddeley and Andrade (2000) demonstrated that the maintenance of auditory and visual images required support from the phonological loop and visuo-spatial sketchpad respectively, as well as having substantial roles for LTM and the central executive. Further research might examine whether some forms of social conjunction processing involve the use of imagery (however, see Hampton, 1996 for use of visual stimuli with non-social conjunctions), and how different elements of working memory may contribute to this. For example, when considering the novel-incongruent conjunction ‘female blacksmith’, it may be useful to develop a mental image of the appearance of such an individual. Indeed, Hastie et al. (1990) discuss ‘mental simulation’ as a form of complex reasoning at stage 2 in their model, and such processes could have a visuo-spatial component. It might also be useful to retain some of the products of complex reasoning processes in a supplementary verbal code, thus drawing on the phonological loop component of working memory. We would still assume that the episodic buffer serves as the workspace within which information from multiple sources, including verbal and visuo-spatial coding (and stored knowledge drawn from LTM), is integrated, and that executive control processes vary in their importance depending on the type of conjunction being formed. Nevertheless, the contributory roles of the different elements of working memory could fruitfully be assessed through the application of dual-task and irrelevant stimulus methodologies, an approach already applied to the study of central executive involvement in conjunctive processing (e.g., Hutter & Crisp, 2006; Hutter & Wood, in press).

Impression formation is a unique process because ultimately it endeavors to explain social behavior, cognition, and motives (Jones, 1998). The present theoretical argument has been mainly concerned with social category combination and associated research, maintaining an impression formation perspective that is founded in social psychology, but integrating recent developments from the working memory literature in order to gain a deeper understanding of the processes involved. There is, however, likely to be considerable overlap between the processing components involved in social and non-social contexts. Indeed, we have shown that Hampton's (1987; 1988) Composite Prototype Model seemingly offers an excellent description of both social and non-social conjunctions, particularly at stage 1. It is therefore entirely plausible that the novel binding of any combination of incongruent elements (from both social and non-social categories) relies heavily on active construction within a component such as the episodic buffer, with processing support from executive resources crucial. Obviously, this is not to claim that there are not unique factors involved in social impression formation (e.g., people possess agency in terms of thoughts and behaviour, while natural categories do not). Nevertheless, such a move would allow a broad view of the cognitive systems underlying binding of different conjunctive elements across a range of contexts.

Finally, while the present work explores aspects of social cognition within the multicomponent model of working memory proposed by Baddeley (Baddeley & Hitch, 1974; Baddeley, 1986, 2012), it is important to note that a number of alternative theoretical approaches to working memory have been proposed (e.g. Cowan, 1995, 1999; Barrouillet, Bernadin, & Camos, 2004; Oberauer, 2002; Oberauer, Suβ, Wilhelm, & Wittman, 2003; Unsworth & Engle, 2007). Various aspects of these models may be usefully applied to the core questions under consideration. For example, Oberauer et al. (2003) identified the coordination of information into integrated structures as being an important facet of working memory. On a different note, Unsworth and Engle (2007) highlighted retrieval of information from secondary memory into primary memory as being a central part of working memory function; this may broadly map onto the retrieval into working memory from LTM of constituent components that we suggest to be important in the formation of novel category conjunctions. However, the alternative models listed above all differ in important ways from the Baddeley multicomponent framework, and therefore are likely to make differing predictions from those set out presently. For example, most alternative models do not accept distinctions between different specialized subcomponents (e.g. for verbal and visuospatial information). Similarly, the clear separation between temporary and long-term memory systems that is assumed by the Baddeley multicomponent model is not supported by several theoretical approaches. For example, the embedded processes model (e.g. Cowan, 1999) instead characterizes working memory as a limited capacity attentional focus within activated LTM. While Baddeley (2012) has argued that his framework and that proposed by Cowan (1999) differ primarily in terms of terminology and areas of focus, it should nevertheless be noted that LTM-based models do not provide a clear explanation of how existing knowledge may be flexibly recombined. Such approaches would not easily address the formation of novel and incongruent social conjunctions, meaning that working memory models incorporating a temporary storage capacity that interacts with but is distinct from LTM may therefore be preferable.

**Conclusion**

The temporary storage capacity and representational qualities attributed to the episodic buffer component of working memory (Baddeley, 2000) strongly suggest that this is the means by which novel conjunctions representations are initially formed and temporarily stored, before allocation to LTM as exemplars. Hutter and Crisp's (2006) and Hutter and Wood's (in press) contention that the generation of emergent attributes is a process reliant on executive resources may only partially be the case and in hindsight require some revision. Given the short-term storage role of the episodic buffer for bound concepts, it seems more likely that: a) the complex reasoning required, at stage 2 in Hastie e al.'s (1990) two-stage model and Hampton's Composite

Prototype model (1987; 1988), to resolve the poor fit between the LTM based constituents in novel-incongruent conjunctions is a function of the central executive and that; b) the temporary storage of the composite is attributable to the episodic buffer regardless of whether stage 1 or stage 2 processing is implicated. In other words, the episodic buffer is active in temporarily storing and representing all forms of novel category conjunctions, but the central executive becomes particularly active in processing novel-incongruent conjunctions. This is in keeping with the episodic buffer as the claimed link between working memory and LTM (Baddeley, 2007), an assumption that remains unexplored. It is possible that other forms of conjunction require binding for example, novel-congruent conjunctions. We have outlined how different forms of conjunction may tap the binding properties of the episodic buffer, and delineated clear predictions regarding which types may particularly require central executive support. It is intended that this theoretical exploration has laid the foundations for potential direction in future investigations of social category conjunction. This is firmly rooted in further developing Hampton's (1987; 1988) Composite Prototype Model and Hastie et al.'s two stage model in conjunction with recent theoretical and empirical developments in Baddeley's (2000) working memory model, resulting in a revised two-stage model. The binding solution for the composite representation temporary storage problem breaks new ground in the social category conjunction literature, but also in the working memory literature, which has yet to significantly empirically address the issue of how pre-existing knowledge is recombined in novel ways. There is a clear role, and indeed requirement, for components with the functions of the episodic buffer (providing workspace and storage) and the central executive (providing processing power) in fully delineating the processes involved in combining or binding novel social category conjunctions.

**References**

Allen, R. J., Baddeley, A. D., & Hitch, G. J. (2006). Is the binding of visual features in working memory resource-demanding? Journal of Experimental Psychology: General, 135, 298-313.

Allen, R. J., Baddeley, A. D., & Hitch, G. J. (2014). Evidence for two attentional components in visual working memory. Journal of Experimental Psychology: Learning, Memory & Cognition, 40 (6), 1499-1509.

Allen, R. J., Hitch, G. J., & Baddeley, A. D. (2009). Cross-modal binding and working memory. Visual Cognition, 17, 83-102.

Allen, R.J., Hitch, G.J., Mate, J., & Baddeley, A.D. (2012). Feature binding and attention in working memory: A resolution of previous contradictory findings. Manuscript submitted for publication.

Anderson, N. H. (1981). Foundations of information integration theory. New York: Academic Press.

Baddeley, A.D. (1986). Working memory. Oxford: Oxford University Press.

Baddeley, A. D. (2000). The episodic buffer: A new component of working memory? Trends in Cognitive Sciences, 4(11), 417-423.

Baddeley, A. D. (2007). Working memory, thought and action. Oxford: Oxford University Press.

Baddeley, A.D. (2012). Working memory: Theories, Models, and controversies. Annual Review of Psychology, 63, 1-29.

Baddeley, A. D., Allen, R. J., & Hitch, G. J. (2010). Investigating the episodic buffer. Psychologica Belgica, 50 (3-4), 223-243.

Baddeley, A. D., Allen, R. J., & Hitch, G. J. (2011). Binding in visual working memory: The role of the episodic buffer. Neuropsychologia. 49, 1393-1400.

Baddeley, A. D., & Andrade, J. (2000). Working memory and the vividness of imagery. Journal of Experimental Psychology: General, 129 (1), 126-145

Baddeley, A. D., & Hitch, G. J. (1974). Working memory. In G. A. Bower (Ed.), The psychology of learning and motivation: Advances in research and theory. (Vol. 8, pp. 47-89). New York: Academic Press.

Baddeley, A. D., Hitch, G. J., & Allen, R. J. (2009). Working memory and binding in sentence recall. Journal of Memory and Language, 61, 438-456.

Baddeley, A. D., & Logie, R. H. (1999). Working memory: The multiple component model. In A. Miyake & P. Shah (Eds.), Models of working memory: Mechanisms of active maintenance and executive control (pp. 28-61): Cambridge University Press.

Baddeley, A. D., Vallar, G., &Wilson, B. A. (1987). Sentence comprehension and phonological memory: Some neuropsychological evidence. In M. Coltheart (Ed.), Attention and performance XII: The psychology of reading (pp. 509–529). Hove, England: Erlbaum.

Barsalou, L. W. (1987). The instability of graded structure: Implications for the nature of concepts. In U. Neisser (Ed.), Concepts and conceptual development: Ecological and Intellectual factors in categorisation (pp. 101-140). Cambridge: Cambridge University Press.

Barsalou, L. W. (1989). Intra-concept similarity and its implications inter-concept similarity. In S. Vosniadou & A. Ortony (Eds.) Similarity and analogical reasoning (pp. 76-121). Cambridge: Cambridge University Press.

Berlingeri, M., Bettini, G., Basilico, S., Silani, G., Zanardi, G., Sberna, M. et al. (2008). Anatomy of the episodic buffer: A voxel-based morphometry study in patients with dementia. Behavioural Neurology, 19, 19-24.

Bodenhausen, G. V. (2010). Diversity in the person, diversity in the group: Challenges of identity complexity for social perception and social interaction. European Journal of Social Psychology, 40, 1–16.

Brewer, M. B, Dull, V., & Lui, L. (1981). Perceptions of the elderly - stereotypes as prototypes. Journal of Personality and Social Psychology. 41(4), 656-670.

Cameron, L., Rutland, A. & Brown, R. (2007). Promoting children's positive intergroup attitudes towards stigmatized groups: Extended contact and multiple classification skills training. International Journal of Behavioral Development, 31(5), 454-466.

Cowan, N. (2001). The magical number 4 in short-term memory: A reconsideration of mental storage capacity. Behavioral and Brain Sciences, 24, 87-185.

Crisp, R. J., & Hewstone, M. (2007). Multiple social categorization. In M. P. Zanna (Ed.), Advances in Experimental Social Psychology (Vol. 39). San Diego, CA: Academic Press.

Daneman, M., & Carpenter, P. A. (1980). Individual differences in working memory and reading. Journal of Verbal Learning and Verbal Behaviour, 19, 450-466.

Darling, S., Allen, R.J., Havelka, J., Campbell, A., & Rattray, E. (2012). Visuospatial bootstrapping: Long-term memory representations are necessary for implicit binding of verbal and visuospatial working memory. Psychonomic Bulletin & Review, 19, 258-263..

Delvenne, J. F., & Bruyer, R. (2004). Does visual short term memory store bound features?. Visual cognition, 11(1), 1-27.

Ecker, U. K. H., Maybery, M., & Zimmer, H. D. (2013). Binding of intrinsic and extrinsic features in working memory. Journal of Experimental Psychology: General, 142(1), 218-234.

Elsley, J. V., & Parmentier, F. B. R. (2009). Is verbal-spatial binding in working memory impaired by a concurrent memory load? Quartely Journal of Experimental Psychology, 62, 1696-1705.

Engle, R. W., & Kane, M. J. (2004). Executive attention, working memory capacity and two-factor theory of cognitive control. In B. Ross (Ed.), The Psychology of Learning and motivation. (pp. 145-199). New York: Elsevier.

Godoy, J.P.M.C., & Galera, C. (2011). Binding faces and names in working memory requires additional attentional resources. Psychology & Neuroscience, 4 (3), 341-346.

Gooding, P. A, Isaac, C, Mayes A. (2005). Prose recall and amnesia: more implications for the episodic buffer. Neuropsychologia, 43 (4), 583-7.

Groom, C. J., Sherman, J. W., Lu, L., Conrey, F. R., & Keijzer, B. S. C. (2005). Judging compound social categories: Compound familiarity and compatibility as determinants of processing mode. Social Cognition, 23(4), 291-323.

Hampton, J. A. (1987). Inheritance of attributes in natural concept conjunctions. Memory & Cognition, 15, 55-71.

Hampton, J. A. (1988). Overextension of conjunctive concepts: Evidence for a unitary model of concept typicality and class inclusion. Journal of Experimental Psychology: Learning, Memory, and Cognition, 14, 12-32.

Hampton, J. A. (1996) Conjunctions of visually based categories: Overextension and compensation. Journal of Experimental Psychology: Learning, Memory, and Cognition, 22(2), 378-396.

Hampton, J. A. (1997). Emergent attributes in combined concepts. In T. B.Ward, S. M. Smith, & J. Viad, (Eds.), Creative thought: An investigation of conceptual structures and processes. pp 83-110. Washington DC: American Psychological Association Press.

Hampton, J. A., Dillane, M., Oren, L., & Worgan, L. (2011). Conjunctions of social categories considered from different points of view. Anthropology and Philosophy. 10, 31-57.

Hastie, R., Schroeder, C., & Weber, R. (1990). Creating complex social conjunction categories from simple categories. Bulletin of the Psychonomic Society, 28, 242-247.

Hemsley, G. D., & Marmurek, H. H. C. (1982) Person memory the processing of consistent and inconsistent person information, Personality and Social Psychology Bulletin, 8, 433-438.

Hu, Y., Hitch, G.J., Baddeley, A.D., Zhang, M., & Allen, R.J. (2014). Executive and perceptual attention play different roles in visual working memory: Evidence from suffix and strategy effects. Journal of Experimental Psychology: Human Perception & Performance, 40 (4), 1665-1678.

Hutter, R. R. C., & Crisp, R. J. (2005). The composition of category conjunctions**.** Personality and Social Psychology Bulletin, 31, 647-657.

Hutter, R. R. C., & Crisp, R. J. (2006). Implications of cognitive busyness for the perception of category conjunctions. Journal of Social Psychology, 146, 253-256.

Hutter, R. R. C., Crisp, R. J., Humphreys, G. W., Waters, G. M., & Moffit, G. (2009). The dynamics of category conjunctions. Group Process and Intergroup Relations, 12(5), 1-15.

Hutter, R. R. C. & Wood, C. (in press). Applying individuation to conflicting social categories. Group Processes and Intergroup Relations.

Hutter, R. R. C., Wood, C., & Dodd, G. F. (2012). Resolving conflicting social categories: The role of age-related executive ability. British Journal of Psychology, 103(1), 28-43.

Jones, E. E. (1998). Major developments in five decades of social psychology. In G. Lindzey and E. Aronson (Eds.) The handbook of social psychology (4th ed., Vol. I, pp. 3-57).

Karlsen, P. J., Allen, R. J., Baddeley, A. D., & Hitch, G. J. (2010). Binding across space and time in visual working memory. Memory and Cognition, 38, 292-303.

Kunda, Z., Miller, D. T., & Claire, T. (1990). Combining social concepts: The role of causal reasoning. Cognitive Science, 14, 551-577.

Kunda, Z., & Thagard, P. (1996). Forming impressions from stereotypes, traits, and behaviors: A parallel-constraint-satisfaction theory. Psychological Review, 103(2), 284-308.

Kyllonen, P. C., & Christal, R. E. (1990). Reasoning ability is (little more than) working-memory capacity? Intelligence, 14, 389-433.

Langerock, N., Vergauwe, E., & Barrouillet, P. (2014). The maintenance of cross-domain associations in the episodic buffer. Journal of Experimental Psychology: Learning, Memory, & Cognition, 40 (4), 1096-1109.

Livesley, W. J. and Bromley, D. B. (1973). Person Perception in Childhood and Adolescence. Oxford; John Wiley and Sons.

Macrae, C. N., Bodenhausen, G. V., Schloerscheidt, A. M., & Milne, A. B. (1999). Tales of the unexpected: Executive function and person perception. Journal of Personality and Social Psychology, 76, 200-213.

Maybery, M. T., Clissa, P. J., Parmentier, F. B., Leung, D., Harsa, G., Fox, A. M., & Jones, D. M. (2009). Binding of verbal and spatial features in auditory working memory. Journal of Memory and Language, 61(1), 112-133.

Morey, C.C. (2009). Integrated cross-domain object storage in working memory: Evidence from a verbal-spatial memory task. The Quarterly Journal of Experimental Psychology, 62 (11) 2235-2251.

Nobre, A. D. P., Rodrigues, J. D. C., Sbicigo, J. B., Piccolo, L. D. R., Zortea, M., Duarte Junior, S., & Salles, J. F. D. (2013). Tasks for assessment of the episodic buffer: a systematic review. Psychology & Neuroscience, 6(3), 331-343.

Murphy, G. L., & Medin, D. L. (1985). The role of theories in conceptual coherence. Psychological Review, 92, 289-316.

Parra, M. A., Fabi, K., Luzzi, S., Cubelli, R., Hernandez Valdez, M., & Della Sala, S. (2013). Relational and conjunctive binding functions dissociate in short-term memory. Neurocase, 1-11.

Oberauer, K. (2002). Access to information in working memory: Exploring the focus of attention. Journal of Experimental Psychology: Learning, Memory, & Cognition, 28 (3), 411-421.

Oberauer, K., Suβ, Wilhelm, & Wittman, W. (2003). The multiple faces of working memory: Storage, processing, supervision, and coordination. Intelligence, 31, 167-193.

Quinn, J. G., & McConnell, J. (1996). Irrelevant pictures in visual working memory. Quarterly Journal of Experimental Psychology, 49A, 200-215.

Rips, L. J. (1995). The current status of research on concept combination. Mind & Language, 10, 72-104.

Roccas, S., & Brewer, M.B. (2002). Social identity complexity. Personality and Social Psychology Review, 6, 88-106.

Siebler, F. (2008). Emergent attributes in person perception: A comparative test of response time predictions. Social Psychology, 39, 83-89.

Smith, E. R. (1990). Content and process specificity in the effects of prior experiences. In T. K. Srull & R. S. Wyer, Jr. (Eds.), Advances in social cognition (Vol. 3, pp. 1–59). Hillsdale, NJ, USA: Lawrence Erlbaum Associates, Inc.

Smith, E. R., & DeCoster, J. (1998). Knowledge acquisition, accessibility, and use in person perception and stereotyping: Simulation with a recurrent connectionist network. Journal of Personality and Social Psychology, 74, 21-35.

Smith, E. E., Osherson, D. N., Rips, L. J., & Keane, M. (1988). Combining prototypes: A selective modification model. Cognitive Science, 12, 485-527.

Stangor, C., Lynch, L., Duan, C., & Glass, B. (1992). Categorization of individuals on the basis of multiple social features. Journal of Personality and Social Psychology, 62, 207-218.

Ueno, T., Allen, R.J., Baddeley, A.D., Hitch, G.J., & Saito, S. (2011). Disruption of visual feature binding in working memory. Memory & Cognition, 39, 12-23.

Unsworth, N., & Engle, R. W. (2007). The nature of individual differences in working memory capacity: active maintenance in primary memory and controlled search from secondary memory. Psychological Review, 114(1), 104.

Van Overwalle, F., & Labiouse, C. (2004). A recurrent connectionist model of person impression formation. Personality and Social Psychology Review, 8, 28-61.

Voorspoels, W., Vanpaemel, W., & Storms, G. (2008). Exemplars and prototypes in natural language concepts: A typicality-based evaluation. Psychonomic Bulletin & Review, 15(3): 630–637.

Wang, S., Allen, R.J., Lee, J.R., & Hsieh, C-E. (in press). Evaluating the developmental trajectory of the episodic buffer component of working memory and its relation to word recognition in children. Journal of Experimental Child Psychology.

Wood, C., & Hutter, R. R. C. (2011). The importance of being emergent: A theoretical exploration of impression formation in novel social category conjunctions. Social and Personality Psychology Compass, 5(6), 321-332.

Zimmer, H., Mecklinger, A., & Lindenberger, U. (2006). Handbook of binding and memory: Perspectives from cognitive neuroscience. Oxford: Oxford University Press.

**Footnotes**

[1]We use the less cumbersome term ‘novel’ henceforth to denote extremely unfamiliar. Familiarity in this manuscript refers to conjunctive familiarity (i.e. female blacksmith) in contrast to constituent familiarity (i.e. female or blacksmith).

[2]We do not discuss Kunda and Thagard’s (1996) Parallel-Constraint-Satisfaction Theory (PCST) because it requires conjunctive exemplars - something that does not exist in novel conjunctions.

[3] It should be noted that Hampton’s model is more usually associated with natural category conjunction (cf. social category conjunctions) and is less usually applied to impression formation (see however, Hampton, 1997; Hampton, Dillane, Oren, & Worgan, 2011)

[4]This ability forms in childhood, indeed, children from approximately 7 to 8 years old seemingly have a sophisticated understanding of multiple simultaneous categorical memberships (e.g., Cameron, Rutland, & Brown, 2007; Livesley & Bromley, 1973).

## Disclosure statement

No financial interest or benefit is associated with the application of this research.