The impact of image format and normative variables on episodic memory

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Abstract: Cognitive processes are complex and difficult to study because multiple variables can interact and confound the effect of the independent variable. To avoid this potential problem, experimental conditions are rigorously controlled and normative stimuli from standardized data-sets are preferably used. However, norms characterize the stimuli, but they do not prevent potential confounding effects. This is an important issue since many normative variables, such as familiarity and visual complexity, influence cognitive processes, such as memory. In Experiment 1, 20 participants completed an episodic memory task in order to see if name agreement, object agreement, familiarity, visual complexity, manipulability and colour diagnosticity of photos taken from the Bank of Standardized Stimuli (BOSS) influence memory performances. In Experiment 2, 20 participants completed a different episodic memory task to see whether memory performances were different for coloured photos, greyscale photos and black and white line drawings. Results showed that familiarity decreased memory accuracy whereas visual complexity increased it. Object agreement and colour diagnosticity brought a feeling of familiarity, and manipulability decreased the recognition of old objects. Results from the Experiment 2 showed that old photos were more recognized than old drawings and that new coloured photos were more correctly rejected than new greyscale photos and new drawings that had low colour diagnosticity. This study documents the different patterns of influences that normative variables exert on episodic memory and illustrates the importance of carefully controlling them in future studies.

ABOUT THE AUTHOR
Mathieu B. Brodeur has been working on memory processes for the last 8 years. Part of his work has been dedicated to the search of variables affecting episodic memory and to the understanding of the brain mechanisms underlying these influences. In this specific article, the influences come from multiple variables, but in previous works, he showed how symmetry, contour, stimulus format, and subject cognitive styles influence episodic memory. These findings were used to study impaired brain mechanisms of memory in people affected with schizophrenia and first episode of psychosis.

PUBLIC INTEREST STATEMENT
Our ability to remember things depends on our memory capacities, our interests and our mental and emotional states. Other influences come from perceptual features of the objects we are looking at like their colours or their complexity. The goal of this experiment was to study how different variables influence our memory. Participants had to memorize and, later on, to recognize photos of objects that differed in terms of their familiarity, visual complexity, manipulability, typicality of their design and colours and the consensus about their names. The influence of the format and colours of the objects was also examined. It was found that these different variables affected memory in different ways, and the way these influences occurred was further examined. This study shed light on the different conditions influencing our memory in general.
1. Introduction

The quality of an experiment relies primarily on how well confounding factors can be controlled. As the field of psycholinguistics has evolved, research has been conducted to identify and control for potential confounds; for example, word-stimuli are verified with regard to the frequency, number of letters, conceptual familiarity, meaningfulness, imageability, concreteness and many other dimensions that could impact the experimental outcome. Some dimensions, such as the number of letters and frequency of words, are objectively measured (e.g. Davis, 2005). However, other dimensions such as familiarity are subjective and require a complete standardized assessment by normative development collected from a sample of subjects. Once collected, norms are usually made available for use in future studies.

While normative word-stimuli banks have been made widely available (e.g. Coltheart, 1981), until the late 1970s, there were no available norms for pictures. Investigators interested in pictures had to develop their own sets that prevented rigorous comparisons between studies due to idiosyncrasies. A turning point in visual stimuli research came in 1980 when Snodgrass and Vanderwart recognized the need for such normalization and published 260 normative pictures of common concrete concepts line-drawn in black over a white background. Snodgrass and Vanderwart (1980) chose to normalize their pictures based on four dimensions: name agreement (the degree to which objects depicted in the picture are identified with the same name across participants), image agreement (the degree to which the mental image generated in response to a word agrees with the picture’s depiction), familiarity with the pictured concepts and the visual complexity of the picture. These four dimensions were selected as they had low intercorrelations amongst one another and were therefore thought to reflect distinct aspects of the pictorial stimuli and to each have a unique influence on naming, recognition and mnemonic processes (Snodgrass & Vanderwart, 1980).

Subsequently, the influence of the norms on naming processes has been widely documented. Name agreement and image agreement have been found to consistently reduce naming latency (Alario et al., 2004; Barry, Morrison, & Ellis, 1997; Cuetos, Ellis, & Alvarez, 1999; Dell’acqua, Lotto, & Job, 2000; Snodgrass & Yuditsky, 1996; Weekes, Shu, Hao, Liu, & Tan, 2007), independent of influences from the name frequency or the age of acquisition of the name in question (Alario et al., 2004; Lachman, Shaffer, & Henrikus, 1974; Vitkovitch & Tyrrell, 1995). Familiarity and visual complexity have also shown to influence naming latency, however less consistently than name and image agreement (Bonin, Perret, Méot, Ferrand, & Mermillod, 2008; Cuetos et al., 1999; Nishimoto, Ueda, Miyawaki, Une, & Takahashi, 2012; Weekes et al., 2007).

Due to the distinct stimulus characteristics that each different normative factor represents, the dimensions contribute to different stages of the picture naming process. The norms have thus helped to better characterize the processes that are involved in naming. For example, visual complexity intervenes on the level of structural analysis required to correctly decode and identify the concept (Alario et al., 2004), whereas image agreement impacts subjects during recognition, showing a link between the concept and stored structural conceptions (Alario et al., 2004). The gathered semantic information activates the production of names and the retrieval of related knowledge from previous exposure to similar stimuli (Alario et al., 2004; Ellis & Morrison, 1998; Feyereisen, Demaeght, & Samson, 1998; Snodgrass & Yuditsky, 1996).

While the normative dimensions proposed by Snodgrass and Vanderwart (1980) have an important influence upon the naming process, their influence on mnemonic processes remains to be investigated. It is expected that normative dimensions have influences on mnemonic processes as
they affect image decoding and the activation of semantic information; both of which are fundamental to memory. For instance, visual complexity is representative of the amount of detail presented in each stimulus (Alario et al., 2004) and these details may encourage the subject to examine the stimulus more completely and thus potentially provide extra information and distinctiveness to the stimuli during encoding and thus impact memory retrieval (Brodeur, Chauret, Dion-Lessard, & Lepage, 2011; Dodson & Hege, 2005; Snodgrass & Corwin, 1988; Wiseman & Neisser, 1974). Details may conversely decrease object familiarity by creating a more specific image and thus the role of visual complexity in recognition remains unclear.

Image agreement may predict memorability and recognition of a stimulus as it serves as a measure of how well a picture matches the stored structural description one associates with a concept (Barry et al., 1997). Image agreement reflects the typicality of stimuli and as such increases the familiarity of a stimulus. How typical and familiar the representation is (Rhodes, Brennan, & Carey, 1987) may therefore improve recognition time of the depicted concept (Dell'acqua et al., 2000). In episodic memory tasks, the feeling of familiarity has been shown to frequently cause subjects to indicate that they had seen the stimuli during the encoding phase—an effect known as the familiarity bias (Snodgrass & Corwin, 1988; Uttl, Graf, & Santacruz, 2006). This bias increases the rate of recognizing encoded items but it also increases the rate of false recognition of novel stimuli. When controlling for similarity bias, Smith and Graesser (1981) found enhanced recall and recognition for atypical stimuli; these findings were explained in that their stimuli were more distinct as compared to typical stimuli.

Familiarity and name agreement, in contrast to visual complexity and image agreement, are specifically related to the semantic information associated with a concept (Alario et al., 2004; Bülthoff & Newell, 2006; Cheng, Schafer, & Akyürek, 2010) and likely have unique effects on memory. The factor “familiarity” differs from the factor “image agreement” in that it reflects the familiarity of the concept and not of the picture. Familiar concepts result in the use of a wider range of encoding strategies than unfamiliar concepts; (Barry et al., 1997; Hollingworth & Henderson, 2002; Hollingworth, Williams, & Henderson, 2001; Kishiyama & Yonelinas, 2003; Melcher & Kowler, 2001; Stewart, Parkin, & Hunkin, 1992) conversely, familiarity could also affect memory by reducing the attention one pays a given stimuli. Additionally, name agreement could affect memory considering the important contribution of verbal information during encoding and recollection of stimuli (Federico & Montague, 1975). For instance, an object with many alternative names increases the need for a mental scan through the alternative names (Lachman & Lachman, 1980), a process that slows down name production (Snodgrass & Yuditsky, 1996) and may slow down encoding processes and reduce the consistency of the stored information. Moreover, consistent name association with a picture reinforces the dual coding of the stimuli (Paivio, 1971; Paivio & Csapo, 1973) integrating both pictorial and verbal information and contributing to more efficient memory retrieval (Snodgrass & McClure, 1975).

Since Snodgrass and Vanderwart (1980) pioneered the normalization of visual stimuli, new dimensions have been added, including manipulability and colour diagnosticity, (Bramão, Inácio, Faisca, Reis, & Petersson, 2010; Filliter, McMullen, & Westwood, 2005; Magnié, Besson, Poncet, & Dolisi, 2003; Tanaka & Presnell, 1999) both of which are expected to influence memory. Manipulability represents the degree to which an object is associated with an action (Magnié et al., 2003). When viewing an object, stored information about the sensory and motor-based attributes of that object can aid in identification (Filliter et al., 2005). In a functional magnetic resonance imaging (fMRI) study, Chao and Martin (2000) illustrated the importance of object manipulability during object name retrieval by demonstrating that when subjects are shown manipulable objects, areas of the brain that store information about previous actions are activated. The influence of manipulability related to recognition was further explored by Mecklinger, Gruenewald, Besson, Magnié, and Von Cramon (2002), who showed that working memory is more accurate for objects that necessitate motor action for use. Moreover, manipulability and memory have been explored in relation to the “enactment effect”
which outlines how performed actions involve more elaborate representations than verbal phrases, and that enacted actions engage the motor system leading to improved recall (Engelkamp & Cohen, 1991; Helstrup, 2004; Madan & Singhal, 2012a).

Colour diagnosticity is defined as the degree to which an object is associated with a specific colour (Tanaka & Presnell, 1999). To illustrate, a banana has high colour diagnosticity because it is most typically yellow, as is a strawberry typically red (Bramão et al., 2010). Results from Bramão et al. (2010) show that colour can trigger one’s access to semantic object information and aid during the encoding phase, subsequently aiding categorization, recognition and name verification of colour-diagnostic objects. Complementing evidence indicates that object shape and name are joined and facilitate name representation access when semantic colour knowledge is activated (Bramão, Reis, Petersson, & Faisca, 2016; Davidoff, Walsh, & Wagemans, 1997; Tanaka, Weiskopf, & Williams, 2001). The main role of colour takes effect when facilitating action at the semantic level, resulting in faster lexical access from memory (Naor-Raz, Tarr, & Kersten, 2003; Rossion & Pourtois, 2004); this remains most effective for objects with high colour diagnosticity (Moreno-Martínez & Rodríguez-Roja, 2015; Nagai & Yokosawa, 2003; Tanaka & Presnell, 1999).

Initial pictorial normative data-sets were limited to black and white drawings; however, recent sets have grown to include both coloured drawings and photographs (Adlington, Laws, & Gale, 2009; Brodeur, Dionne-Dostie, Montreuil, & Lepage, 2010; Moreno-Martínez, Montoro, & Laws, 2011; Rossion & Pourtois, 2004; Shao & Stiegert, 2016; Viggiano, Vannucci, & Righi, 2004). This change in pictorial format, like changes in norms, could affect mnemonic processes as picture format has been shown to influence naming production and memory. Although controversial and heavily debated (Tanaka et al., 2001), much literature supports the assertion that colour aids in object recognitions and naming. This is evidenced in studies conducted by Brodie, Wallace, and Sharrat (1991) and Tanaka et al. (2001) whereby object naming and recognition were faster and improved when the stimuli were presented as coloured photographs as compared to line drawings. More recently, Heuer (2016) found that in a recognition task, coloured photographs were fixated for a longer period of time than line drawings photographs. However, Biederman and Ju (1988) found little effect of colour on object recognition and Fu et al. (2016) showed that natural scene categorization is primarily processed on the basis of edge-based information like lines in a drawing. Nevertheless, colour is important for object recognition and naming, particularly when information about object shape is less accessible (Bramão, Reis, Petersson, & Faisca, 2011). This effect of colour is particularly relevant if objects come from categories thought to have greater structural similarity, like animals, (Price & Humphreys, 1989; Wurm, Legge, Isenberg, & Luebker, 1993), and when the colour is diagnostic to the identity of the object (Tanaka & Presnell, 1999; Tanaka et al., 2001).

While colour has influence on naming and recognition processes, the addition of colour has also been found to influence episodic memory. Cave, Bost, and Cobb (1996) presented evidence that indicated that pictorial stimuli were more accurately recognized following a 48 h delay when stimuli were presented in the same colour vs. when presented in a different colour. This finding suggests that colours enrich encoded information and contribute to recognition. Furthermore, the format of a presented stimulus can play a role in recognition. Tatler and Melcher (2007) found that when presented with photographic and non-photographic images, subjects performed better in object memory tests for the photographic images. Similarly, Davies, Ellis, and Shepherd (1978) conducted an experiment whereby subjects were shown photographs and detailed line drawings of unknown faces. In a recognition test, photographs were consistently recognized more often than the line-drawn versions.

Overall, research suggests that name agreement, image agreement, familiarity, visual complexity, manipulability and colour diagnosticity, in addition to image format and the presence of colour can all affect episodic memory performance. The first goal of the present study is to examine how the normative dimensions affect responses in a classic episodic memory experiment. Stimuli were taken from the Bank of Standardized Stimuli (BOSS) (Brodeur et al., 2010) and performance was analysed...
as a function of the norms. A second experiment using coloured photographs, greyscale photographs and black and white line drawings was conducted to examine the influence of image format and colour on recognition memory. Discovering the influence of normative dimensions, picture format and colour on performance emphasizes the importance of controlling for these variables to prevent their confounding effect on memory performances in future studies.

2. Experiment 1

2.1. Method

2.1.1. Subjects
Twenty English-speaking volunteers (13 female, 7 male), mean age = 20.5 (SD: 0.7) were recruited through ads posted on local university campuses. All volunteers signed an informed consent form approved by the Research Ethics Board of the Douglas Mental Health University Institute and were compensated 10 Canadian dollars for participation.

2.1.2. Stimuli
Stimuli were taken from the BOSS; a visual set that includes previously normalized photos of objects (Brodeur et al., 2010). The BOSS originally included 538 photo stimuli from which 58 were removed from the publication due to low name agreement. An additional 22 photographs were removed: 13 of which were due to modal names deemed as incorrect in O'Sullivan, Lepage, Bouras, Montreuil, and Brodeur (2012), and the remaining nine photographs were removed because they were correctly named by less than 50% of the subjects in the normalization process. The remaining 458 stimuli used in this experiment included only common objects such as pencil, computer mouse and comb. Examples are illustrated in Figure 1.

2.1.3. Norms
The norms used in the BOSS include name agreement, familiarity, visual complexity, object agreement, viewpoint agreement and manipulability (Brodeur et al., 2010) and were collected from other participants than those who participated in this study. Except for the names, all norms were obtained by averaging the ratings of 33 to 39 subjects on a scale of 1 to 5 (e.g. 5 being very familiar and 1 being very unfamiliar). Name agreement was converted into a percentage that reflects the greatest proportion of 39 subjects agreeing on the same name to a presented object. The H-statistic was calculated to give an index of variability of the names participants gave for an image. However, due to the very high correlation between the H-statistic and the modal name agreement, the H-statistic was omitted from further analysis. Object agreement and viewpoint agreement were also highly correlated (Brodeur et al., 2010). Object and viewpoint agreements are the extents to which a mental representation respectively matches the concept depicted in an image and its position. Since the object agreement was most similar to the norm of image agreement introduced by Snodgrass and Vanderwart (1980), only this norm was kept for the study.

![Figure 1. Examples of stimuli used in Experiment 1.](image)

Notes: The first row includes an object with a low name agreement and five objects with low ratings on each normative variable. The second row includes objects with high name agreement and high ratings.
In the current study, colour diagnosticity was included as an additional norm. The colour diagnosticity norm was acquired by subjecting 32 volunteers (15 females, mean age: 36.8, SD: 14.1) to the BOSS stimuli and asking them to indicate on a scale of 1 to 5 (5 = highly typical) to what extent the colour is typical of the object, stating: “rate the level to which the colour is typical of the object”. To ensure accurate colour perception of all volunteers, each volunteer was assessed using the Pseudo Isochromatic Plates Ishihara Compatible Test (Waggoner, 2005). Results from this data were analysed following the standard normative procedure used for all BOSS normalization. These new norms can be downloaded from the BOSS website: https://sites.google.com/site/bosstimuli/home.

In summary, norms measured in the present study were: name agreement (NA), familiarity, visual complexity (VC), object agreement (OA), manipulability and colour diagnosticity (CD).

2.1.4. Procedure
Participants were brought into the testing room and were seated in front of a computer screen. The task began with an encoding session during which subjects were presented with half of the stimuli (229), one at a time, on the computer screen. The instruction at encoding was to determine whether the object was smaller or larger in reality than the object previously presented. Five minutes post encoding task, subjects were invited to complete an unexpected recognition session whereby they were presented with all previously encoded pictures randomly mixed with the remaining 229 pictures that were not presented initially. Participants were asked to determine whether the presented picture was an “old” (seen before) or “new” (never seen) picture, indicated by pressing designated keys on the keyboard. The keys used to represent “old” and “new” pictures were interchanged for half of the subjects. The stimuli were presented for 2,500 ms during encoding and for 2,000 ms during recognition. The presentation of all stimuli was preceded by a fixation cross appearing for 500 ms.

2.1.5. Data analyses
The first analyses were conducted on the norms of the photo stimuli to see whether these norms were different across old and new conditions. The analyses were conducted with objects as for the subjects and with the norms as for the dependent variable. Thus, the old/new condition was a between-group variable. In a second set of analyses, bivariate correlations were used to explore the inter- and intra-relations between norms for both the old and new conditions. The alpha threshold for the t-tests and the correlations was Bonferroni-adjusted to 0.0083.

The influence of the norms on memory was examined by analysing three measures of performances of the 20 participants recruited for this study: the hit (old objects correctly classified as old), the correct rejection (CR; new objects correctly classified as new) and the response bias (Br; indicates the probability of classifying a stimulus as either “old” or “new” when uncertain about classification) (Snodgrass & Corwin, 1988). Br is expressed as FA/[1−(hit−FA)]. FA refers to the false alarm rate (1−CR). To facilitate understanding and comparison of the Br, 0.5 was subtracted and resultanty a value of 0 signifies no bias. A positive value indicated that subjects had a response bias towards familiarity, meaning there was a tendency to classify pictures as old. A negative value corresponded to a novelty bias, meaning there was a tendency to classify pictures as new.

For the analyses on memory performance, stimuli were half-split as a function of each norm (i.e. the lowest ratings in one half subset and the highest ratings in the other subset). Examples of objects with high and low ratings for each norm are presented in Figure 1. Differences of hit (for old), CR (for new) and Br between the subsets of stimuli (i.e. the two halves) were compared using pairwise t-tests. Bonferroni-adjusted significance level of alpha threshold was set to 0.0083. The influence of the norms on memory performance was further examined by regressing each norm rating with the hit of the old pictures and the CR rate of the new pictures.

The two subsets of stimuli created after splitting low and high ratings on one norm were not necessarily matched with regards to the other norm. Thus, these other norms were compared as they
could potentially act as confounds. When they significantly differed between two subsets, the statistical comparisons between the two subsets were rerun with the confounding norms as covariates.

2.2. Results

Table 1 presents the mean norms of the old and new stimuli, along with the statistical results of their comparison using t-tests. There were no significant differences.

Table 2 presents the correlational analyses between norms. Name agreement was related to familiarity, object agreement and manipulability. Other significant correlations were found between familiarity and object agreement, and between object agreement and colour diagnosticity. Familiarity also significantly correlated with colour diagnosticity for new objects.

The old and the new stimuli were split in subsets (i.e. halves) as a function of the highest and lowest ratings of each norm. All norms of these subsets were computed and statistically compared. The norm used for splitting the subsets was necessarily significantly different between subsets but Table 3 shows that some of the other norms also significantly differed. For example, the old objects with a high familiarity rating also had higher rates of name agreement and object agreement than objects with low familiarity rating.

### Table 1. Norms of old and new stimuli in Experiment 1

| Norms | Old | New | Stats* |
|-------|-----|-----|--------|
| Mean  | (SD) | Mean | (SD)   |        |
| NA (%)| 65.83 | 22.07| 65.52  | 23.16  |
| t     | 0.144, p = 0.885 |
| Fam   | 4.07 | 0.40| 4.02  | 0.41  |
| t     | 1.221, p = 0.223 |
| VC    | 2.40 | 0.43| 2.42  | 0.44  |
| t     | −0.397, p = 0.692 |
| OA    | 3.93 | 0.52| 3.93  | 0.54  |
| t     | 0.184, p = 0.854 |
| CD    | 4.18 | 0.41| 4.22  | 0.36  |
| t     | −0.886, p = 0.376 |
| Manip | 2.59 | 0.75| 2.55  | 0.81  |
| t     | 0.523, p = 0.601 |

Notes: NA = name agreement, Fam = familiarity, VC = visual complexity, OA = object agreement, CD = colour diagnosticity, Manip = manipulability.

*Degree of freedom = 19.

### Table 2. Correlations of normative dimensions

|       | NA  | Fam | VC  | OA  | CD  |
|-------|-----|-----|-----|-----|-----|
| **Old stimuli** |     |     |     |     |     |
| Fam   | 0.387* |     |     |     |     |
| VC    | −0.017 | −0.116 |     |     |     |
| OA    | 0.212* | 0.323* | −0.047 |     |     |
| CD    | 0.065 | 0.168 | −0.039 | 0.356* |     |
| Manip | 0.214* | 0.183 | 0.017 | 0.096 | −0.027 |
| **New stimuli** |     |     |     |     |     |
| Fam   | 0.389* |     |     |     |     |
| VC    | −0.195 | −0.191 |     |     |     |
| OA    | 0.390* | 0.427* | −0.118 |     |     |
| CD    | 0.136 | 0.290* | 0.032 | 0.383* |     |
| Manip | 0.220* | 0.186 | 0.124 | 0.038 | −0.077 |

Notes: NA = name agreement, Fam = familiarity, VC = visual complexity, OA = object agreement, CD = colour diagnosticity, Manip = manipulability.

*p < 0.0083.
Analyses of memory performances show that the overall hit rate was 69.8% (SD: 11.8) and CR was 89.3% (SD: 7.5). The CR rate was significantly higher than the hit rate ($t(19) = -6.047, p < 0.001$). Br was −24% (SD: 15.5%) and this was significantly different from 0 ($t(19) = -6.917, p < 0.001$), indicating that there was a strong novelty bias.

Figure 2 presents the hit, CR, and Br of objects with the highest and lowest value of each norm. Objects with higher familiarity ratings had a significantly lower hit (67%, SD: 13%) and CR rates (87%, SD: 9%) than objects that were the least familiar (Hit: 73%, SD: 12%, $t = -4.148, p < 0.001$ and CR: 91%, SD: 7%, $t = -3.475, p < 0.001$). As the familiarity rating was associated with similar ratings of name agreement, object agreement and colour diagnosticity, analyses were conducted with these ratings as covariates. The hit rate remained significantly higher ($F > 13.500$) for least familiar objects. However, the greater CR for least familiar objects was no more significant with the object agreement and colour diagnosticity as covariates ($F < 1.73$). On the contrary, higher visual complexity was associated with higher hit (72%, SD: 12%) and CR rates (91%, SD: 7%) as compared to lower visual complexity (Hit: 68%, SD: 12%, $t = 3.137, p = 0.005$ and CR: 88%, SD: 9%, $t = 4.437, p = 0.005$). No covariates were included in this analyses as the other norms had all been controlled for between

| Table 3. Comparison of norms across subsets of stimuli in Experiment 1 |
|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
|                | NA          | Fam          | VC            | OA            | CD            | Manip         |
| Old stimuli    |             |              |               |               |               |               |
| NA             | High        | 85.45*       | 4.22*         | 2.41          | 4.04*         | 4.23          | 2.72          |
|                | Low         | 47.05*       | 3.92*         | 2.40          | 3.83*         | 4.13          | 2.47          |
| Fam            | High        | 72.63*       | 4.40*         | 2.36          | 4.06*         | 4.24          | 2.66          |
|                | Low         | 58.96*       | 3.73*         | 2.65          | 3.80*         | 4.12          | 2.52          |
| VC             | High        | 66.35        | 4.03          | 2.74*         | 3.90          | 4.17          | 2.60          |
|                | Low         | 65.33        | 4.10          | 2.08*         | 3.97          | 4.19          | 2.59          |
| OA             | High        | 70.69*       | 4.18*         | 2.42          | 4.34*         | 4.30*         | 2.66          |
|                | Low         | 60.83*       | 3.95*         | 2.38          | 3.51*         | 4.05*         | 2.52          |
| CD             | High        | 66.91        | 4.11          | 2.41          | 4.07*         | 4.51*         | 2.56          |
|                | Low         | 64.83        | 4.03          | 2.60          | 3.81*         | 3.88*         | 2.62          |
| Manip          | High        | 69.26        | 4.12          | 2.60          | 4.00          | 4.15          | 3.18*         |
|                | Low         | 62.12        | 4.01          | 2.61          | 3.86          | 4.21          | 1.96*         |
| New stimuli    |             |              |               |               |               |               |
| NA             | High        | 85.60*       | 4.16*         | 2.34          | 4.10*         | 4.24          | 2.71*         |
|                | Low         | 45.27*       | 3.88*         | 2.50          | 3.74*         | 4.19          | 2.40*         |
| Fam            | High        | 71.39*       | 4.36*         | 2.36          | 4.09*         | 4.30*         | 2.65          |
|                | Low         | 59.71*       | 3.69*         | 2.49          | 3.77*         | 4.13*         | 2.46          |
| VC             | High        | 61.12*       | 3.95          | 2.76*         | 3.84          | 4.22          | 2.62          |
|                | Low         | 70.12*       | 4.09          | 2.07*         | 4.01          | 4.21          | 2.48          |
| OA             | High        | 73.73*       | 4.15*         | 2.40          | 4.39*         | 4.36*         | 2.57          |
|                | Low         | 58.57*       | 3.91*         | 2.64          | 3.53*         | 4.09*         | 2.54          |
| CD             | High        | 68.01        | 4.12*         | 2.65          | 4.10*         | 4.50*         | 2.57          |
|                | Low         | 62.87        | 3.91*         | 2.39          | 3.74*         | 3.91*         | 2.53          |
| Manip          | High        | 70.02*       | 4.07          | 2.47          | 3.95          | 4.19          | 3.27*         |
|                | Low         | 61.51*       | 3.98          | 2.38          | 3.90          | 4.24          | 1.91*         |

Notes: NA = name agreement, Fam = familiarity, VC = visual complexity, OA = object agreement, CD = colour diagnosticity, Manip = manipulability.

*p < 0.0083.
Objects with high ratings of object agreement (73%, SD: 11%) and colour diagnosticity (73%, SD: 11%) had a significantly higher hit rates than objects with lower ratings (object agreement: 67%, SD: 14%, \( t = 4.670, p < 0.001 \); colour diagnosticity: 67%, SD: 13%, \( t = 5.401, p < 0.001 \)). The effect was in the opposite direction for the CR, meaning that the CR was significantly lower for objects with high rating of object agreement (87%, SD: 8%) and colour diagnosticity (87%, SD: 8%) than for objects with low rating of object agreement (91%, SD: 7%, \( t = −4.016, p < 0.001 \)) and colour diagnosticity (91%, SD: 7%, \( t = −4.212, p < 0.001 \)). Object agreement and colour diagnosticity were significantly correlated (Table 2). The p-values for the object agreement effect on old (\( F(1,18) = 3.94, p = 0.063 \)) and new (\( F(1,18) = 5.65, p = 0.029 \)) were above the corrected alpha threshold when colour diagnosticity was the covariate and the same finding occurred for the colour diagnosticity effect with object agreement as the covariate (old: \( F(1,18) = 7.89, p = 0.012 \); new: \( F(1,18) = 6.74, p = 0.018 \)). Name agreement and familiarity, which covaried with object agreement and colour diagnosticity, had no impact on the significance of the results (\( F’s > 7.40 \)). As for the novelty bias, it was significantly smaller for objects with high rating of object agreement (~19%, SD: 17%) and colour diagnosticity.
Objects that rated high on manipulability were significantly less recognized (67%, SD: 12%) than objects that rated low on manipulability (72%, SD: 13%, $t = -4.098, p < 0.001$). Name agreement was added as a covariate and the difference remained significant ($F = 14.70$). CR and Br were not significantly affected by manipulability. Name agreement had no significant influence on Hit, CR and Br.

In the last series of analyses, correlations were examined between the norms, the hit rate and the CR rate. Familiarity and visual complexity were correlated with the hit rate ($r = -0.199, p = 0.002$ and $r = 0.151, p = 0.022$, respectively) and the CR ($r = -0.183, p = 0.006$ and $r = 0.136, p = 0.039$, respectively). The correlation was negative for the familiarity and positive for the visual complexity. Object agreement and colour diagnosticity were positively correlated with the hit rate ($r = 0.172, p = 0.009$ and $r = 0.173, p = 0.009$, respectively) but negatively correlated with the CR ($r = -0.153, p = 0.020$ and $r = -0.177, p = 0.007$). Finally, manipulability was only negatively correlated with the hit rate ($r = -0.202, p = 0.002$). No significant correlation was obtained for name agreement.

2.3. Discussion

This study illustrates the effects of normative dimensions on memory performance through three different patterns. The first pattern demonstrates a modulation of memory accuracy resulting from a simultaneous increase in hit rate and correct rejection. Familiarity and visual complexity exhibit this pattern; accuracy was better for unfamiliar objects and more complex objects. The second pattern of note is an increase of hit rate in combination with decreased correct rejection, resulting from a familiarity memory bias. This pattern was observed following the analyses performed as a function of object agreement and colour diagnosticity. The third pattern consists of an increased hit rate. This was found for objects that had a low manipulability rating. Name agreement had no significant impact on episodic memory. These patterns were observed following comparisons between subsets of stimuli. Similar patterns were obtained when looking at the correlations between the performances associated to an object and its respective normative ratings.

The initial pattern found was a synchronous increase in hit and correct rejection rates; this pattern was clear for objects rated for familiarity. In previous studies, familiarity was found to enhance the long-term (Goldstein & Chance, 1971), associative (Reder et al., 2013) and short-term memory (Jackson & Raymond, 2008; Xie & Zhang, 2016) of various types of stimuli. It is also known that experts familiar with a specific domain can recall (Johnson & Kieras, 1983) or recognize (Brandt, Cooper, & Dewhurst, 2005) more material from this familiar domain than non-expert individuals. Similar advantages of familiarity were expected for the present study however results show that memory accuracy was greater for more unfamiliar objects. The discrepancy is likely due to divergence in the way familiarity is conceptualized. Goldstein and Chance (1971) interpreted their familiarity effect as the consequence of frequent inputs. However, repetition leads to a familiarization to the pictorial information which is more likely reflected by the object agreement than by the actual familiarity with the concept. Familiarity has also been found to help recognition when stimuli such as faces, were highly similar across the set and required deeper encoding to be accurately discriminated (Goldstein & Chance, 1971). There was no such condition of similarity in the present study and the task was incidental, meaning that the participants were unlikely to have initiated deep mnemonic encoding, especially when the objects were familiar and required little attention to be recognized. In turn, when presented with unfamiliar objects, participants have likely allocated more attention to the image when attempting to identify the object. Therefore, unfamiliarity acted in this study like the condition of similarity in previous studies by increasing the need for deeper encoding.

Memory accuracy was affected by a variation of visual complexity. This finding is congruent with other studies showing better memory performance for detailed pictures vs. less detailed or schematic pictures (Denis, 1976; Peeck & Van Dam, 1978; but see Pezdek & Chen, 1982). This finding could result from a more thorough examination of the former stimuli as was claimed by Jesky and
Berry (1991) when they found that the addition of visual details in a stimulus increases the capacity of memory storage and retrieval. Increasing the number of visual details gives more options to detect differences between objects and to discriminate the old ones from the new ones (Severin, 1967). As was the case for familiarity, similarity of stimuli counteracts an effect of visual complexity; if stimuli are more complex and they are difficult to discriminate from one another, this will impede correct recall (Goldstein & Chance, 1971; Jackson, Linden, Roberts, Kriegeskorte, & Haenschel, 2015). This does not apply to our experiment since all objects were different. Further, recall has been found to be better for more complex pictures if they are presented intermixed with simple pictures and not presented in separate blocks (Peeck & Van Dam, 1978; Peeck, Van Dam, & Uhlenbeck, 1977), as was the case in the present study.

It must be noted that in some circumstances, simpler versions of images can lead to better recall. For instance, Ritchey and Beal (1980) found that outline drawings with no details inside of them had better recall than did detailed drawings. However, this effect, replicated by Coulter, Coulter, and Glover (1984) (see also Rock, Halper, & Clayton, 1972), likely followed extra imagery effort provided to complete the simpler version of the stimuli. Such effort was not required in the present study for the least complex photo stimuli. Moreover, Homa and Viera (1988) also found more accurate recognition for simple drawings compared to more detailed drawings. However, these drawings were characterized by numerous unimportant and confusing details that may have impacted the interpretation of the images and as such we find that memory performance was improved with stimuli of greater complexity.

Although familiarity and visual complexity both influenced accuracy of memory performance, they likely each have distinct effects because the two dimensions were uncorrelated (Table 2) and because each dimension was controlled when analysing the other dimension (Table 3). Familiarity and visual complexity were also unlikely affected by other normative variables except the effect of familiarity on CR rate which turned out to be not significant when covaried with the object agreement and colour diagnosticity. The higher rate of CR for the least familiar objects, compared to the more familiar objects, could thus be due to the atypicality of the least familiar objects.

A second pattern of memory performance noted was a high hit rate combined with a lower correct rejection rate (i.e. a higher false alarm rate), indicating a response bias whereby the subjects tend to respond “old” overall. Objects with high object agreement and colour diagnosticity elicited this familiarity bias. This means that the more similar an object is to one’s own personal visual representation, the more prone one is to believe that this object has been seen before. Since there was an overall novelty bias in the task, the familiarity biases induced by object agreement and colour diagnosticity were expressed by an overall reduction of the novelty bias. The correlation between object agreement and colour diagnosticity and their similar pattern of influence on memory performance was expected as they are two measures of the object typicality or familiarity with the visual representation of the concept (Smith & Medin, 1981). Likely, the effects of colour diagnosticity and object agreement reflect the same source of influence which is dependent on how distinctive the object is from its typical representation.

Our findings on the influence of object agreement is intuitive but contrasts with several previous findings. For example, atypical or distinctive faces have frequently been found to be better recognized and correctly rejected than typical faces, suggesting that atypicality increases memory accuracy (Cohen & Carr, 1975; Going & Read, 1974; Light, Kayra-Stuart, & Hollander, 1979). While this effect could be attributed to a deeper encoding resulting from a greater allocation of attention (Hastie & Kumar, 1979), it may be the case that the better performance with atypical faces is caused by mistakes made when presented with typical faces, and more specifically, with new faces. Bartlett, Hurry, and Thorley (1984) showed that when subjects are not familiarized with the faces beforehand, typical faces are more falsely recognized than unusual faces. Higher rate of false alarms for objects that are visually closer to an idiosyncratic prototype have been previously reported (Franks & Bransford, 1971), and can be explained by the exemplar-based model (Gillund & Shiffrin, 1984).
When a new item is initially perceived, it is compared to stored memory items. When new items resemble stored items they are more familiar and less distinctive, thereby increasing the rating of object agreement and the chance of confounding the perceived items with the stored items (Zaki & Nosofsky, 2001).

A third pattern of memory performance was that it is affected by manipulability. New objects were unaffected by manipulability while old objects that were less manipulable tended to be better recognized than old object that were more manipulable. This effect is in contradiction of a study done by Madan and Singhal (2012b) in which it was shown that words that referred to manipulable concepts were better recalled than words referring to non-manipulable concepts. However, in this same study, it was also shown that recall was better for non-manipulable objects when an intermediate level-of-processing, focusing on the use of the objects, was used during encoding. Other advantages were also reported for non-manipulable objects with processes that could potentially improve memory; non-manipulable objects are categorized (Salmon, Matheson, & McMullen, 2014), and matched with a corresponding word (Fillitier, McMullen, & Westwood, 2005) more quickly than manipulable objects. Identifying perceptual similarity relations is also easier to execute with non-manipulable objects than with manipulable objects (Kalenine & Bonthoux, 2008). Currently, it cannot be determined whether it is the manipulability that affects recognition or non-manipulability that increases it; however, this study shows and influence of manipulability on memory.

3. Experiment 2

3.1. Method

3.1.1. Subjects
A new cohort of twenty English-speaking healthy volunteers (14 female, 6 male), mean age = 20.8 (SD: 1.0) were recruited to participate in the second experiment of this study. Volunteers were recruited through ads posted in local newspapers and on local university campuses. Each volunteer had normal or corrected to normal vision, signed an informed consent form approved by the Research Ethics Board of the Douglas Mental Health University Institute and received a compensation of 10 Canadian dollars for participation.

3.1.2. Stimuli
Stimuli were taken from the original BOSS (Brodeur et al., 2010). Some stimuli were also taken from the add-on set of stimuli from the BOSS (Brodeur, Guérard, & Bouras, 2014). The stimuli consisted of 140 coloured photographs, 140 greyscale photographs and 140 black and white line-drawn versions of photographs. Examples of stimuli are presented in Figure 3.

3.1.3. Norms
To isolate the effect of stimulus modality, dimensions that have an impact on memory performance were controlled. This necessitated the collection of additional norms for greyscale photographs and line drawings. New norms were collected from two new groups of healthy subjects. The first group
evaluated the greyscale photographs and was composed of 15 females and 10 males (mean age: 24.7, SD: 8.3). The second group evaluated the line drawings and was composed of 19 females and 6 males (mean age: 22.4, SD: 4.3). Instructions given to subjects for these norms were the same as were for the coloured photographs. More information about those norms can be found at https://sites.google.com/site/bosstimuli/. The instructions for evaluating colour diagnosticity had to be adapted as colours were not perceived in the greyscale and line-drawing stimuli. The instruction was therefore changed to “Rate the level to which the colour(s) generally associated with this object is or are typical of the object”.

All dimensions were normalized for these stimuli except for name agreement as it failed to influence memory performance in Experiment 1. These norms were controlled by matching them as much as possible across the experimental conditions. The only norm that was used as an independent variable was the colour diagnosticity because of colours’ influence on performance in various tasks including naming and object recognition (Humphrey, Goodale, Jakobson, & Servos, 1994; Rossion & Pourtois, 2004; Tanaka & Presnell, 1999; Therriault, Yaxley, & Zwaan, 2009). Colours that are highly diagnostic provide no distinctive information that can be used to facilitate memory retrieval and memory performance. For instance, the colour of a banana is meaningless in the sense that it is typically yellow. On the other hand, the colour of a shirt provides information that enriches encoding because it helps distinguish this shirt from another shirt of a different colour. The present study will examine whether the expected effect of colours is of smaller magnitude for objects with high CD.

### 3.1.4. Procedure

The same experimental design and instructions were employed as in Experiment 1. Half of the stimuli (70 from each condition) were presented at encoding and recognition; the remaining stimuli were presented only at recognition as new stimuli. As in Experiment 1, the task was incidental, meaning that subjects were not warned of the recognition phase when they completed the encoding phase.

### 3.1.5. Data analyses

The first analyses were performed to see if there were differences between the norms of the three conditions of stimuli. As in Experiment 1, objects were entered in the statistic model as subjects, norms were the dependent variable, and the stimulus format (coloured photographs, greyscale photographs and line drawings) was the between-group variable. The alpha threshold for this ANOVA was Bonferroni-adjusted to 0.0017.

**Table 4. Norms across the stimulus conditions of Experiment 2**

| Note       | Colour | Greyscale | Drawing | Stats* |
|------------|--------|-----------|---------|--------|
|            | Old    | New       | Old     | New    | Old    | New    | Mean (SD) | Mean (SD) | Mean (SD) | Mean (SD) |            |
| Fam        | 4.34 (0.50) | 4.26 (0.48) | 4.47 (0.42) | 4.40 (0.54) | 4.45 (0.50) | 4.55 (0.36) | F = 3.289, p = 0.006 |
| VC         | 2.64 (0.44) | 2.43 (0.46) | 2.65 (0.79) | 2.63 (0.64) | 2.49 (0.73) | 2.65 (0.72) | F = 1.538, p = 0.177 |
| OA         | 3.72 (0.60) | 3.83 (0.51) | 3.88 (0.72) | 3.67 (0.72) | 3.76 (0.65) | 3.82 (0.69) | F = .967, p = 0.438 |
| CD         | 4.07 (0.46) | 4.01 (0.45) | 3.04 (0.76) | 2.99 (0.76) | 2.84 (0.79) | 3.00 (0.76) | F = 46.999, p < 0.001 |
| Manip      | 2.40 (0.27) | 3.41 (0.37) | 3.13 (0.91) | 3.00 (0.79) | 3.06 (0.89) | 3.20 (0.74) | F = 16.275, p < 0.001 |

Notes: FAM = familiarity, VC = visual complexity, OA = object agreement, CD = colour diagnosticity, Manip = manipulability.

*Degree of freedom = 419.
Analyses of the performances of the 20 participants were completed separately for the Hit, CR and Br and consisted of ANOVAs with the stimulus format (coloured photos, greyscale photos and line drawings) and the colour diagnosticity as the within-subject variables.

### 3.2. Results

Table 4 presents the mean norms of the old and new stimuli in each of the three stimulus formats along with the statistical results of their comparison using one-way ANOVAs. Visual complexity and object agreement were not significantly different across conditions and familiarity did not pass the Bonferroni corrected threshold of 0.0017. T-tests performed between conditions indicate that the colour diagnosticity was significantly greater for the colour photos than for all other conditions (all t’s (138) > 9.065 and p’s < 0.001). Manipulability for old coloured photos was significantly smaller than all other conditions (all t’s (138) > 5.884 and p’s < 0.001). In addition, manipulability for new colour photos was significantly greater than new greyscale photos (t(138) = 3.908, p < 0.001). Because the p-value was close to the Bonferroni threshold, t-tests were also conducted for familiarity. The only significant difference was found between the familiarity of new coloured photos and new drawings (t(138) = 4.044, p < 0.001).

Results for 19 subjects are presented in Figure 4. One subject was removed due to a CR rate of 14%, thus 5 SD below the average. The ANOVA showed that stimulus format significantly influenced...
the hit rate (F(2,36) = 7.010, p = 0.003). T-tests conducted between the different stimulus format showed that the hit rate was significantly smaller for line drawings than for coloured photos (t(18) = 3.043, p = 0.007) and greyscale photos (t(18) = 2.797, p = 0.012).

Format significantly interacted with colour diagnosticity for CR (F(2,36) = 3.767, p = 0.033) but not for hit and Br. The CR rate for coloured photos with a low colour diagnosticity was significantly greater than the CR rate for coloured photos with high colour diagnosticity (t(18) = 2.251, p = 0.037) and for greyscale photos (t(18) = 2.632, p = 0.017) and line drawings with low colour diagnosticity (t(18) = 2.501, p = 0.022).

Finally, Figure 4 illustrates differences of Br between conditions; however, there was no significant effect.

3.3. Discussion
The present study finds that photographic images are more often recognized line drawings. Colours were of impact when comparing coloured to greyscale photos, and the colour diagnosticity had no influence on the difference between photographic images and the drawings. Therefore, the stimulus format, more than the colours, was the determining variable of the recognition performance. On the other hand, the CR was dependent upon the colours and the colour diagnosticity. The CR was enhanced for coloured photos compared to greyscale photos and drawings but only for objects with a low CD, objects which are not typically associated with a specific colour. Therefore, the hit and CR rate are affected differently by the stimulus format and colouration.

While the advantage of visual stimuli over verbal material on memory has been largely documented, the way visual dimensions and stimulus format drives this advantage remains undetermined. Contradictory effects of stimulus format on memory performance have been reported. On one side, better memory performance for photos relative to black and white drawings has been shown by Loftus and Bell (1975) and other research teams (Davies et al., 1978; Tatler & Melcher, 2007; Tversky & Baratz, 1985) in memory recognition tasks and by Jesky and Berry (1991), Berry (1991a), and Madigan and Lawrence (1980) in recall tasks. Conversely, several studies found no difference of memory recognition (Anglin & Levie, 1985; Madigan, 1983; Nelson, Metzler, & Reed, 1974) and recall (Tversky & Baratz, 1985) between photos and drawings. Memory performances involving coloured and black and white photos were found to be either superior or comparable to drawings (Anglin & Levie, 1985; Berry, 1991a; Jesky & Berry, 1991). However, the method of retrieval used to assess memory performance was likely impactful as the lack of a stimulus format effect was reported more often in memory recognition tasks than in recall tasks. It is also noteworthy that recognition of coloured photos is better than simple drawings in an old/new recognition task but not in a force-choice task where subjects must remember the source of the format at encoding (Homa & Viera, 1988). The present results do not settle the stimulus-format effect debate but they strengthen the argument that photos are better recognized than drawings. In addition, the present results indicate that stimulus format has no impact on the processing of new objects. As there was no difference in CR between greyscale photos and drawings, the differences of CR between coloured photos and drawings is likely attributable to the colours and not the photographic format.

The advantage of photographic format over drawings is arguably a matter of the quantity and quality of cues used for encoding and retrieving the stored information. Photos thus facilitate the retrieval because they have more distinctive cues and more informative details than drawings (Denis, 1976; Loftus & Bell, 1975). These details add to the visual complexity of the stimuli (Berry, 1991a) and as such, the stimulus format could influence memory like visual complexity did in Experiment 1. While the comparison of the visual complexity effect and the stimulus format effect cannot be statistically tested, the increase of memory recognition due to increased visual complexity and photographic format are likely similar.
Per Berry (1991a), cues from more “ecological” or realistic stimuli are effective encoding devices that offer more “handles” with which to store and subsequently retrieve information. This assumption, called the realism theory, predicts better performance for photos than drawings and is supported by results of this study. However, this theory assumes that realistic cues facilitate encoding because they more likely match the actual representations in memory. As such, photographic stimuli should influence memory as object agreement did in Experiment 1 and produce a familiarity bias. This interpretation of the stimulus format effect is not consistent with the present results considering that stimulus format did not induce such bias.

Colour was the second variable of interest. Its influence was studied by comparing coloured and greyscale photos, a comparison that revealed no significant difference of hit rate but a difference of CR for objects with low colour diagnosticity. Other studies have explored the influence of colours on memory; most reported and analysed only the recall, the hit rate and/or the accuracy performance. Like stimulus format, colours influence memory in a very inconsistent manner across studies and its effect seems to be dependent on the types of memory retrieval and on whether stimuli are photos or drawings. In Berry (1991b), recall was not significantly enhanced for coloured photos relative to black and white photos (see also Katzman & Nyenhuis, 1972) but Jesky and Berry (1991), and Homa and Viera (1988) found an advantage for coloured photos. Memory recognition was also examined. In Berry (1977) and other studies using scene stimuli (Spence, Wong, Rusan, & Rastegar, 2006; Suzuki & Takahashi, 1997; Wichmann, Sharpe, & Gegenfurtner, 2002), there was an advantage for coloured photos over black and white and greyscale photos but no such advantage was found in Anglin and Levie (1985). It has been found that colours enhance recall and memory recognition in drawings, but not photos or black and white drawings (Borges, Stepnowsky, & Holt, 1977; Borges et al., 1977; Bousfield, Esterson, & Whitmarsh, 1957; Denis, 1976); contrarily, the absence of any difference has also been reported (Paivio, Rogers, & Smythe, 1968).

The presence of colour was expected to enhance memory performance because it provides more information to encode and acts as a cueing device at recognition. With this view, the congruity of colours is irrelevant, meaning that the presence of colour enhances memory even when it is inappropriately applied. Several studies support this view. For instance, relative to black and white photos, coloured photos had a beneficial effect on recognition even when the colours were altered in an unrealistic way (Berry, 1977; Cave et al., 1996; Wichmann et al., 2002). Berry (1991a) argued that colours are more than simply extra cues because they add to the realism of pictures. He supported his assertion through a review of numerous works consisting primarily of doctoral dissertations (Berry, 1991a) and other studies, (Berry, 1990, 1991b; Borges et al., 1977) showing better recall for photos realistic (i.e. appropriate) colours than unrealistic (inappropriate) colours. Moreover, Wichmann et al. (2002) showed that memory accuracy in a recognition task was marginally higher in realistic coloured photos than in non-realistic coloured photos.

With the multitude of conflicting findings and results in the literature, the influence of colour on memory has not yet been clarified. In fact, numerous variables including arousal, attention and cues can dictate or modulate the effect of colours on memory (Dzulkifi & Mustafar, 2013). In the present study, many potential confounds were controlled for and the photos were of high quality and yet, colours had no impact on memory recognition. It must be noted that the greyscale photos used in the present study had different tones of luminance and as such, they provided richer surface details than did the black and white photos used in the 70s. The prediction that colours would enhance memory recognition of objects with low colour diagnosticity because colours are more useful than in objects with high colour diagnosticity was not validated. This is consistent with the absence of a diagnostic colour effect described by Wichmann et al. (2002). Having colours that are less diagnostic helps to detect new objects, this means that colour diagnosticity can help discriminate new objects from old objects.

The effect of colours in the present study was limited to new stimuli. To our knowledge, performance on new items has rarely been examined. In Berry (1990), the false alarm rates seem to be
higher for realistic colours compared to non-realistic colours. While these effects were not statistically tested, and are difficult to compare to the current results, they nevertheless show that colours influence the way one responds to new items. Contrarily, Wichmann et al. (2002) used scene stimuli and found no significant difference of performance on the new items in their recognition task between coloured and greyscale photos.

The distinctiveness heuristic (DH) strategy could explain why the effect of colour depended on the colour diagnosticity. The DH is a studied phenomenon that proposes a reliance on distinctive features of something to remember it (i.e. a subject thinking “if I had seen this object, I would remember it”) and proceed to a rejection if no distinctive memory comes to mind (Dodson & Schacter, 2002). The DH is a strategic process that operates during retrieval. For instance, when presented with a red banana, one notes and reflects on the difference of this from a regular banana, vs. when presented with a yellow banana, no extra thought processing is necessary. It is through this DH strategy that we believe that objects with low colour diagnosticity cause subjects to pay more attention to the uniqueness of the object, resulting in a higher CR for objects with less colour diagnosticity. Conversely, objects presented in their typical colour (e.g. yellow banana) are more typical and familiar, less novel and are therefore rejected less often as participants feel they have seen them before. The DH is only plausible if the subject sees the actual colours, which was the case for the coloured photos but not for the other conditions, thus explaining why CR was increased for coloured photos. However, it must be kept in mind that the instruction was different for coloured objects and greyscale/drawings. The fact that the subjects could not see the colours of the greyscale and drawing when deciding whether the objects were associated with specific colour may have affected their rating. With coloured photos, subjects were not only rating the colour diagnosticity but also judging whether the actual colour was diagnostic.

4. General discussion

The aim of the present study was to examine the effects of normative variables and different image formats on episodic memory. Two experiments were conducted using two separate sets of English speaking participants who were subjected to episodic memory tasks involving normative variables and different stimulus formats. It was found that familiarity and visual complexity influenced memory accuracy while object agreement and colour diagnosticity induced a familiarity bias and manipulability affected recognition rate. It was also found that photos were more recognized than drawing and that colours increased the CR of objects that had low colour diagnosticity.

The present results show that common normative variables and stimulus formats can influence memory recognition in various ways. The only variable that had no significant effect on recognition, correct rejection and/or memory bias was the name agreement. This finding is surprising given the documented influence that this variable has on cognitive processing (Alario et al., 2004; Bülthoff & Newell, 2006) and even brain activities (Cheng et al., 2010; Kan & Thompson-Schill, 2004). However, this finding must be interpreted carefully considering that name agreement correlated with familiarity and object agreement.

Among the influences observed in this study, it was found that objects that were less familiar and visually more complex were better recognized or correctly rejected. This is likely because, being less familiar and more visually complex, these stimuli captured more of the participants’ attention and lead to a more thorough examination of all the details of the stimuli. In doing so, this likely increased the amount of information to encode and retrieve from memory, making the stimuli more distinguishable (Denis, 1976; Peeck & Van Dam, 1978; but see Jesky & Berry, 1991; Pezdek & Chen, 1982; Severin, 1967). Object agreement and colour diagnosticity likely shared a common factor as their influence on memory was very similar. High ratings for these two variables signifies that the object appears as is expected by the participant after reading the objects’ name and thus, it is not surprising that these two variables increased the feeling of familiarity. The last normative variable to influence memory was manipulability. Manipulability decreased the hit rate. While this result is arguably consistent with other studies reporting an advantage for less manipulable objects (Fillitier et al., 2005;
Kalenine & Bonthoux, 2008; Salmon et al., 2014), its influence on memory remains to be explained. Finally, stimulus format and stimuli with low colour diagnosticity influenced the recognition of old items and the correct rejection of new items, respectively. Stimulus format offers more modal information to encode whereas colour provides information that can be used to recognize a new object.

The effects of normative variables and stimulus format on memory are inconsistent across studies. Our results support the observations from some studies but are also in contradiction with other studies. For instance, the effects of normative variables like familiarity or colour diagnosticity have been largely studied in the last decades and to date there exists no consensus about how they affect cognition and its components, such as episodic memory. The effects described in the literature are dependent on many conditions such as the discriminability of the stimuli, the type of memory retrieval, the number of stimuli and the instructions at encoding (Ritchey, 1982). For instance, Knopf (1991) found an advantage for unfamiliar items in recognition memory task and an advantage for familiar items in recall memory tasks. Additionally, the advantage afforded by familiarity is lost when items are presented within contexts or if not enough time is given to the subjects to verbalize the items (Brandt et al., 2005; Del Castillo & Gumenik, 1972; Johnson & Kieras, 1983). Another source of variability across studies is related to the way that normative variables are defined or manipulated. Familiarity is a clear example of this dilemma; it can refer to the concept or the picture and it can be induced by asking subjects to study stimuli, by repeating stimuli, by comparing experts vs. non-experts (Brandt et al., 2005), etc. The present experiment was designed to be as close as possible to reality by using incidental memory tasks and by using norms.

The conditions dictating how normative variables influence memory remain to be explored; however, documentation of discovered influences is critical to research as they can have many confounding effects if not adequately controlled. This is even more important for shared sets of stimuli used in different laboratories worldwide, as is the case for the BOSS. The results of this study are instrumental to the field of cognitive science as they aid in improved control over confounding factors for studies involving episodic memory tasks, an important marker of cognitive performance, and integral component of daily cognitive functioning (Baddeley, 1992) and thus improve the quality and creditability of an experiment.

The present results should nevertheless be used cautiously considering some limitations. To begin with, some norms are correlated meaning that it may not be each norm per se that influences the memory but a common factor. This is obviously the case for norms like object agreement and colour diagnosticity which are highly correlated. However, the common factor that may underlie the relation between name agreement, familiarity and object agreement is less clear and may require further investigation. Another limitation is the narrow range of variability in the ratings of several norms. This is the case, for example, of familiarity. Objects of the BOSS are mostly familiar meaning that those included in the less familiar condition are not necessarily unfamiliar. The influence of the norms on memory must thus be interpreted by keeping in mind what is opposed when comparing condition of higher ratings vs. lower ratings.

In summary, the present study provides evidence for the effects of normative variables and stimulus format on memory. The evidence presented assists the research in the field of memory and cognitive function and provides grounds for improved standardization allowing researchers to further explore memory by controlling for variables and selecting stimuli that have specific, controlled for, effects on episodic memory. This study focused on common normative variables provided by the BOSS but other variables should also be considered in future studies including animacy (e.g. Nairne, VanArsdall, Pandeirada, Cogdill, & LeBreton, 2013) and norms related to the name of the objects like imageability (e.g. Klaver et al., 2005) and age of acquisition.

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