Associative Context Encoding in Individuals with Schizophrenia: Contributions of Strategic and Automatic Processes.

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ABSTRACT

Neuropsychological research of schizophrenia indicates an impairment of episodic memory. It has been hypothesized that this impairment might arise from encoding deficits based on relational binding of associative information. Evidence shows that memory involving contextual association is disproportionately impaired in schizophrenia. Similarly, poor performances are also evoked in tasks where memory performance is based on *controlled* processes that support these memories, whereas more *automatic* processes of familiarity are relatively intact. The process-dissociation procedure paradigm developed by Jacoby and colleagues has been used to provide evidence of independence in these systems and estimate their contributions in memory tasks. The current study uses this procedure to estimate the effects of automatic and controlled influences on 1) Contextual organisation for successful retrieval; and 2) Use of beneficial strategies using the level-of-processing paradigm. The results using opposition procedure estimates demonstrated reduced recollection familiarity among individuals with schizophrenia in conditions that did not support strategic use of context. This is consistent with the hypothesis of a specific context-processing deficit in schizophrenia.

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LIST OF TABLES AND FIGURES

Tables

Figures

TABLE OF CONTENTS

Page

Before neuropsychological research, understanding of schizophrenia was formed by findings from two basic levels of investigation; at the biological level, it was considered abnormal neurological functioning of uncertain aetiology; at the behavioural level, it was studied as a syndrome featuring an array of heterogeneous symptoms that feature perceptual aberrations and distorted reasoning. However, explanations of the pathways of how these domains combine to form the schizophrenic experience were impoverished, due to insufficient detail of how these deficits were connected. Insight from how these factors are mediated at the neuropsychological level has led to a wave of neuroscientific research over the last two decades. As cognitive research began to fractionate the mind into discrete processes, impaired cognition became the characteristic profile of the disorder (Danion, Huron, Vidailhet & Berna, 2007). These approaches are guided by cognitive models, generating test-ready hypotheses of how cognition in deviates from normal functioning, and offers predictions of neural activity from brain-imaging that can strengthen interpretations of findings.

Individuals with schizophrenia experience a wide-range of cognitive disturbances with impairments seen in virtually every function (Danion et al., 2007). Despite this, certain components are disproportionately impaired while a select few are remarkably intact. Along with components of attention and working memory, episodic memory (EM) has shown to be consistently impaired in schizophrenia (for a review see Aleman, Hijman, de Haan & Kahn, 1999). Research has been motivated by the finding that episodic memory impairments - more so than clinical symptoms - are related to poorer functional outcomes (Green, Kern, Braff & Mintz, 2000). An attempt will be made to show how findings from schizophrenia research has helped refine current concepts of episodic memory and opened up new approaches of investigation.

Models of Episodic Memory from Neuroscience

Studies of impairments in EM are guided by models of memory to functionally define the damaged theoretical subcomponents. They are therefore limited in their interpretations to the extent that the models of cognitive processes reflect their *true* anatamo-functional basis in the brain. Tulving (1972) was among the first to challenge the unitary concept of memory when he distinguished between

episodic and semantic memory. Episodic memory was defined as the recall of detailed autobiographical events embedded in a specific time and place. He proposed that consciously reliving a past event was the defining feature of episodic memory. Semantic memory included loosely based information such as factual knowledge and skills that were not attached to any personal experience. He predicted that awareness of semantic knowledge could be made conscious but could also be accessed unconsciously through feelings of familiarity and implicit knowledge of previous experience. He received support from studies showing that amnesiacs showed enhanced priming effects when words were associatively related: a strong indication of the implicit use of semantic memory (Shimamura & Squire, 1984). Tulving (1983) later deduced that the different levels of awareness underlying these components must represent the two completely separate memory systems of explicit and implicit memory. Indeed, two years later Tulving (1985) reported that subjects could accurately report which of the processes they were engaging by reporting whether they 'remember' from full *recollection,* or merely 'know' it occurred before due to feelings of strong *familiarity*. These processes were thought to contribute respectively to the distinct systems of explicit and implicit memory.

Gardiner and Richardson-Klaehn (1990) developed the subjective reports of 'remembering' and 'knowing' into an experimental paradigm to study differential effects of variables on explicit and implicit memory. Research findings have since become more detailed by also distinguishing between encoding, storage and retrieval stages of memory. With this level of complexity, researchers were able to analyze effects of subtle influences of independent variables. Gardiner, Richardson-Klaehn and Java (1996) tested the effects of type of encoding using a level-of-processing paradigm (LOP), which sees stimuli processing occurring at varying levels of 'depth'. Deep processing is determined by the extent to which the stimulus can form connections to pre-existing memories or is meaningfully elaborated and processed with a high degree of effort (Craik & Lockhart, 1972). Encoding of a stimulus at the 'shallow' depth occurs only in terms of its physical characteristics, such as phonological or orthographical properties (e.g., the case in which a word is printed). From the results, deeper processing appeared to enable subjects to report much higher rates of recognition, but only for remember responses. In another experiment, Greg and Gardiner (1994) manipulated the study and test modality so that subjects encoded items visually at study, then given a visual or verbal recall test. Recognition was

decreased but only responses of knowing were affected. Changing modalities (or other salient features) between encoding and retrieval appeared to change the processes they engaged at these stages. The break in process compatibility led to poorer memory performance, a finding which initiated an approach to investigations of memory known as the transfer-appropriate processing (Morris, Bransford & Franks, 1977).

Table 1. Summary of results from Gardiner et al. (1996) and Greg and Gardiner (1994).

Variable	Condition	Overall	Remember	Know
Level-of-Processing	Semantic	0.90	0.72	0.18
	Graphemic	0.35	0.15	0.20
Study/test modalities	Visual/Visual	0.63	0.11	0.52
	Visual/Auditory	0.37	0.10	0.27

The summary of findings in Table 1 show how different variables can influence explicit and implicit processes of recognition memory separately. Early conclusions from these studies were that explicit networks seem to involve more conscious elaboration of stimuli while implicit networks favour perceptual input. Recently however, findings have been reported of perceptual variables that influence remembering (Mantyla, 1997) and conceptual variables that influence knowing (Rajaram, 1996), indicating that the process distinction of conceptual and perceptual input were not directly parallel with state of awareness. To reconcile these findings, Rajaram (1996) revised the theory, stating that remembering is dependent of the distinctiveness of memories and familiarity of knowing is a function of processing fluency (or passive automaticity of a task, i.e., from over-practise etc.).

Support for the distinctiveness/fluency framework came from the finding that recognition of a picture is affected by size congruency between study and test. This perceptual variable was found to occur in remembering but not in knowing (Rajaram, 1996). The distinctiveness of the picture encoding is presumably improved if the size of the picture is the same at study and test. From this view of the relationship between state of awareness and processing depth, deeper processing can lead to memories being more conceptually formed, and therefore more distinctive. This perspective sees conceptual driven processes as those that access semantic and associative networks

that relate and distinguish features of stimuli. Notably, it shows how deeper processing can therefore afford finer detail of conscious elaboration, improving the selective power of search efforts for retrieval from conscious awareness.

Measuring Consciousness

Modern dual-process theories of memory consider conscious awareness to be the yardstick of recollection. To reflect this central importance of awareness, they have replaced implicit and explicit systems of EM with the theoretically parallel processes of recollection and familiarity (Jacoby, Yonelinas, Toth & Debiner, 1994). Within this framework, familiarity is considered an *automatic* process, occurring outside of conscious awareness while recognition is regarded as requiring additional process of *controlled* attention (Jacoby, 1993). The theory features additional dissociable attributes of these processes. Importantly, but not surprisingly, studies of processing speed demonstrate that familiarity is significantly faster than recollection. Under shorter response deadlines, participants were found to make more accurate judgments on familiarity based features, such as if a word is new or has been previously studied, than if they had to retrieve specific contextual features of the study phase, such as when and where the word was presented (Hintzman & Caulton, 1997).

Theories like those described above are defined by their independence of processes assumption. What distinguishes the theoretical approach developed by Jacoby, Yonelinas and Toth (1993) is that it focuses more on the relationship of conscious and unconscious memory contributions rather than their exclusivity. Raganath, Minzenberg and Ragland (2008) provide a real-life example of this relationship, adapted slightly for our purposes: if you are attempting to recall where you left your keys, you would be forced to initiate a strategic search in which you generate a prior context (e.g., “I was in my office”) to generate more specific retrieval cues (e.g., “Did I leave the keys in the desk drawer?”). Under these circumstances, control processes are critical, because it is necessary to plan and focus on goal-relevant information. On the other hand, automatic influences can also aid in recollection like if you have a very familiar designated ‘key place’ you might seek them there. In this case, both processes are working in *concert* to boost recollection of the event. If you are attempting to recognize whether a face corresponds to someone you have previously met, you can rely on a sense of how familiar that person seems or

recollect details that might be automatically elicited after viewing the person's face (e.g., "I saw that person last night"). Even in this case, however, cognitive control can be helpful, because it is sometimes necessary to inhibit irrelevant information that might be recovered. For instance, if the person looks similar to someone else you met at the same party you might incorrectly recall details of that person instead, an example of controlled and automatic influences working in *opposition.*

Investigating the relative contributions of recollection and automatic processes is at the forefront of this type of research (Jacoby et al., 1996). The approach arose out of dissatisfaction with the questionable practise of identifying processes using tasks, as done by indirect tests of memory (e.g., priming paradigms and tests of perceptual learning). Such tests claim to capture effect of familiarity by "obscuring the relationship between test and study phases" (Linscott and Knight, 2001, p. 576) or showing evidence of strategic improvement without awareness. However, accuracy in these tests cannot confidently propose to reflect automatic processing as no experimental control is exerted over what processes are used at encoding and retrieval. Even in the most indirect or covert of tasks, subjects maintain the ability to use intentional awareness to remember stimuli. Likewise, direct tests of explicit memory are vulnerable to automatic influences. Such influences increase the chances for correct guessing and inflate measures of recollection (Jacoby, 2003). In estimating effects of recollection and familiarity, Jacoby concludes that standard implicit and explicit tasks may not be "process pure" (Jacoby, 1991, p. 531).

Overcoming this limitation motivated the development of a new method called process-dissociation procedure (PDP). Whereas previous measures attempt to isolate the distinctive systems, this technique uses tasks that differentially manipulate their relationship (i.e. whether they both contribute to recall or not). As shown, automatic and controlled influences can work in concert or in opposition, depending on the nature of the task. By measuring the performance of both these tasks in parallel, it is possible to quantify their individual contributions to recollection. In the first study using this design, the separate influences of automatic and controlled processes of memory were studied (Jacoby, Toth & Yonelinas, 1993). Subjects were given a list of words to remember and they were then presented with the stems of the studied words for completion. Instructions for the word-stem completion task were different depending on whether it was the exclusion task; where participants were instructed to complete word stems with unstudied words, or the inclusion task; where studied word

production was encouraged. In the exclusion task, the selective response of rejecting "old" words in the exclusion task is a strictly controlled process afforded only by recollection of the original event. In contrast, automatic processes are assumed not to support such selective responding, thereby creating an 'in opposition' dynamic. They act to increase the probability of completing word stems with those old words regardless of whether an exclusion or an inclusion task is given.

This effect can be seen in Stroop task findings, in which strategic responding is impeded by automatic influences (Barch, 2004). Results showed that by dividing attention during study, recollection can be reduced to zero (Jacoby, Toth & Yonelinas, 1993). Therefore, any responding with old words in the exclusion test must be purely automatic. Estimates of purely recollection influences under full attention can then be derived by subtracting the automatic estimates under divided attention. By dividing attention, the PDP seeks to produces dissociations on the estimates of different types of processes.

Table 2. Probabilities of responding with an old word and estimates of recollection (*R*) and automatic influences (*A*) from Jacoby et al. (1993).

	Probabilities test		Estimates	
Attention	Inclusion	Exclusion	*R*	*A*
Full	0.61	0.36	0.25	0.47
Divided	0.46	0.46	0	0.46

As seen from Table 2, dividing attention had the effect of eliminating recollection. This was derived from the finding that the probability of responding with an old word under divided attention was equal whether it was an exclusion task or an inclusion task, which was above the base rate (0.46>0.35) providing clear evidence of automatic influences. Recollection was sufficient to return old word responding to baseline in the exclusion task, further confirming the accuracy of the automatic process estimate. Jacoby's (1991) claims of pure process assumption were therefore well founded as during recollection responding was primarily under automatic influence. Another limitation of direct memory tests is that they do not allow us to examine automatic influences within recollection. If responding from the inclusion task was taken as a measure of recollection (as with typical direct tests), the estimate

of recollective influences would be grossly inflated. The PDP carries with it some theoretical assumptions. As it is based on dual-process theories of memory, recollection and familiarity are considered to act independently. However, if this assumption can be violated then the dissociable estimates must be dismissed as chance (Jacoby & Jennings, 1997). More of its limitations will be discussed later, but as will be suggested in the present study, the PDP has special significance for the study of cognitive deficits in schizophrenia.

Episodic Memory in Schizophrenia

It is well documented in schizophrenia research that patients perform poorly in tasks of EM (for a meta-analysis see Heinrichs & Zakzanis, 1998). This deficit is of particular interest to neuroscience as studies have consistently shown it to be a stable and mediating deficit in schizophrenia (Toulopoulou & Murray, 2004), unrelated to general cognitive impairment or attention (Danion et al., 2007). Also, it has show to be present before full onset of the condition and as such can serve as an early marker for high-risk individuals (Brewer et al., 2005), which will be discussed in more detail later. These findings are promising indications that EM may offer insight into the neuropathology of the disease. For example, the fact that EM deficits are present regardless of medication status signifies that it is not just incidental to non-specific abnormal neural functioning and may be a primary mediating feature, core to the disease's aetiology (Stratta et al., 2000).

Recall refers to the ability to actively retrieve the information sought from memory stores, whereas recognition involves determining whether a particular stimulus has previously been learned (Brébion, Amador, Smith & Gordan, 1997). Research shows that schizophrenic individuals are impaired on tests of both recognition and recollection. However, using the same breakdown of EM as that described above and with recent evidence that offer increased resolution of memory organisation, a specific theme of impairment can be identified. In a review of the meta-analyses performed on effect sizes of the deficits between the tests, Danion et al. (2007) concluded that recollection was more severely impaired in schizophrenia than recognition. This impairment can be further specified by findings that dissociate effects at encoding and retrieval. Brébion, David, Rodrigo, Bressan and Pilowsky (2006) performed a study to investigate which stage of memory was most disturbed

by presenting semantically-organizable and non-organizable lists. Following study, subjects were administered either a cued recognition or free-recall test. Results showed that schizophrenic patients did not use the semantic properties of the words to encode the information as much as controls. Even when provided with cues, patients failed to benefit from organizational strategies compared to controls: a clear indication of failure to properly encode the items in the first place.

As well as confirming encoding deficits, this evidence also reveals inefficient processing at deep levels of contextual elaboration. Studies of LOP effects on memory suggest these encoding strategies are supported by the same controlled processes that support recollection at retrieval. Thus, before it is proposed that this is evidence of a contextual processing deficit, it is important to clarify if it was incidental to an overall impairment of controlled processing or indicative of a more specific process disturbance in patients' associative networks. Contextual information typically involves features of the encoding event that fall outside the focus of awareness, such as the source of the target (self or other) or some property of the target to relate it to the encoding event (e.g. semantic category of item or physical feature of item). In a study by Ragland and colleagues (2003), patients with schizophrenia were tested on reality-monitoring, whereby patients have to discriminate if an item was self-generated or came from an external source, requiring binding of the target item to its 'source' feature. This demonstrated deficit is considered to have major clinical implications: individuals with schizophrenia are more liable to attribute self-generated thoughts and visions to the external environment, making them susceptible to the type of hallucinations and delusions documented in positive symptomology (Frith, 1994). Subjects were provided with shallow (uppercase/lowercase) and deep (abstract/concrete) encoding strategies and then given either a recognition test or a recollection test. It was found that deep encoding improved recognition performance with no differences between the groups. The LOP effect was not found for patients in the recollection condition, however. From a dual-process perspective of memory, it appears that schizophrenic patients were only able to benefit from semantic organisation if retrieval can be based mostly on familiarity effects as in cued recognition. The actual semantic network of schizophrenia patients was intact enough to support automatic retrieval of relational information if the specific relations were made consciously aware (i.e. if controlled processing at encoding was externally complimented). Strategies of semantic

organisation are therefore not necessarily disrupted in schizophrenia, but rather have difficulty being expressed. In a similar study by Danion et al. (2007), they interpreted this finding as a problem of self-initiation. Recognising the availability of such strategies in everyday life requires semantic knowledge of stimuli so that it may be juxtaposed with other stimuli and associations formed. Episodic memory therefore requires access to semantic memory to form meaningful memory traces.

Two prevailing models have been proposed to explain dissociable performances in automatic and controlled processing in schizophrenia: (1) there is a hyper-activated association network in schizophrenia that might be used to explain the inappropriate intrusions of associations into schizophrenic speech (Spitzer, Braun, Hermle & Maier, 1993a) or (2) there is a higher-level strategic impairment in how patients semantically organise information for ease of integration and retrieval from this network that might predict the delusional and paranoid tendencies that arise from failing to reality-monitor (Barch et al., 1996). In the hyper-activated network hypothesis, language and memory impairments arise from a core deficit in the automatic processing mode (Maher, 1987). Findings used to support this approach also suggest strong links between hyper-activation and thought-disorder exhibited in a high proportion of patients. Thought disorder (TD) is characterised by aberrations in speech such as loosing of associations, clanging and intrusions. Spitzer et al. (1993a) uses an extract of dialogue to illustrates typical TD speech:

> One patient of the first author (M.S.) spontaneously produced the phrase ‘computer-no city’. A few seconds later, he commented that ‘Nixdorf’ makes computers (‘Nixdorf’ is the name of a German computer company, whose name, ‘nixdorf’, literally means ‘no village’), and this way, he had gone from ‘computer’ via ‘Nixdorf’ (no village) to ‘no city’. This example illustrates that there may be many cases of indirect associations in which we just miss the ‘link’, and therefore find the flow of associations in our patients’ thoughts totally incomprehensible.(p. 864)

From this perspective, excessive semantic activation leads to this unfocused speech pattern. Recognising the same phenomenon, the context-processing deficit hypothesis regards this as an inability to use context to constrain the degree to which associations are formed. Speech then becomes driven indiscriminately by ‘local’ neighbouring associations, as opposed to global associations in which context can be

applied to define relational criteria. One problem with attempting to isolate dissociable variables that would allow us to validate these hypotheses is that their theories might not be exclusive but, to some extent, intrinsically linked. For instance, a hyper-activated network would predict context to be ineffectual to channel the boundless spread of activation. In a circular logic, the limited expression of semantic strategies might result in the same excited network postulated by a hyper-activated approach. However, in the context of widespread cognitive impairment it seems like a more parsimonious explanation that schizophrenia would result in an impaired system and not an enhanced one. In the subsequent sections is a review of evidence in support of both interpretations from research on effects of priming.

Evidence from Stroop Tasks

In the last decade, a growing number of studies have used the Stroop task to investigate selective attention in schizophrenia (Barch et al., 1996; Taylor, Kornblum & Tandon, 1996; Everett, Laplante & Thomas, 1989). In this task, participants are presented with words printed in colours and are instructed to identify the print colour and ignore the word under three conditions: (a) congruent (colour and word are the same, such as the word RED written in red ink), (b) neutral (a noncolour word printed in some ink colour, such as the word DOG written in red ink), and (c) incongruent (colour and word conflict, such as the word BLUE written in red ink). Healthy participants had faster reaction time (RT) for naming the colour of a word in the congruent condition than in the neutral condition, an effect referred to as *Stroop facilitation.* In contrast, RTs become slower in naming the ink colour in the incongruent condition than in the neutral condition, an effect referred to as *Stroop interference.* A prepotency to read the word is thought to require selective inhibiting, reducing performance speed for colour naming (Cohen, Servan-Schreiber, & McClelland, 1992).

Interestingly, despite demonstration of wide-spread impairments, patients with schizophrenia show an increased facilitation effect but not an increased interference effect compared to normal participants (Carter et al., 1992). This was coupled with an increase in response error interference, resulting in faster but less accurate responses. Initially these findings were used in support of hyperactive network, whereby abnormal automatic processing led to faster and stronger response strengths. Other

studies have provided evidence that contests these claims. Barch, Carter and Cohen (2003) revealed the studies use to support the surprising lack of an increase in the interference effect were flawed on methodological grounds. Firstly, the interference effect is measured by the difference between the incongruent and neutral conditions. Thus, if the RTs of patients are increased in both the neutral and the incongruent conditions, the overall magnitude of their RT interference effect might not appear enhanced compared with that of control participants.

Secondly, increased error rates of patients in the incongruent condition were also distorting performance measures. In healthy individuals, responses are slower in the incongruent condition because the influence of the target word interferes with the naming of the colour. When tested, it was found that deficits of selective attention are so severe in patients with schizophrenia that on some trials, not only are responses slower but they are incorrect, with the word being responded to instead of the colour (i.e., increased errors). Because estimates of the interference effect use only RTs for correct trials, the increase in errors may serve to eliminate those trials on which the patients had the most difficulty. Slowing was still evident on remaining trials, but with the trials potentially most sensitive to the interference effect eliminated (i.e., errors), any significant effect was lost. In light of this evidence, the arguments for the lack of interference effect become very uncertain. The 'schizophrenia enhanced' facilitation effect was also challenged by Barch and colleagues (1999) by using a paradigm from semantic priming (SP) research. They predicted that if the hyperactive semantic network interpretation were to hold true, then schizophrenic patients that showed increased facilitation effects should also show enhanced facilitation effects. Findings on the effects automatic processing in SP research of schizophrenia have shed light on the hyperactive network vs. context-processing debate. However, results from SP have been plagued by inconsistency, so it is important that any inferences are judged by the reliability of their findings.

Evidence from Semantic Priming

SP studies investigate how knowledge is extracted from, and strategies are applied to, semantic memory. To visualise the nature of semantic memory, many theories have adopted an approach from psycholinguistics, where a web-like network of conceptually connected nodes is used to representing knowledge graphically

(Rosch, 1999). These networks are thought to be analogous to neural networks, with connections of varying length and connectivity based on degree of functional relatedness (Minzenberg, Vinogradov & Ober, 2002). In semantic priming paradigms such as word pronunciation (WP) and lexical-decision task (LDT), a prime and a target are presented in close succession. In WP participants pronounce the target word, whereas in LDT they decide whether the target is a valid English word. An effect known as SP consistently occurs when responses are faster if the target is semantically or associatively related to the prime than if they are not (Meyer & Schvaneveldt, 1971). Both spreading activation and higher-level strategic processes are thought to contribute to this effect, reflecting automatic and controlled processing respectively. Strategies thought to involve controlled influences are *expectancy* (i.e., a subset of possible responses are selectively activated by a prime and *matching* (i.e., a strategy that only occurs in LDT where the participant looks back to a previously presented prime or checks and notices that there is a semantic relationship between the prime and target, then the participant will be biased to verify the word as real, qualified by the words semantically related prime) (Minzenberg et al., 2002).

To tease apart effects of spreading activation and higher-level influences, researcher use short and long stimulus onset asynchronies (SOA: the difference in onset between two consecutive stimuli). SOAs under 300ms are generally considered to represent automatic influences as they preclude controlled processing (Barch et al., 1999). To investigate the aforementioned Stroop facilitation effect in schizophrenia, Barch and colleagues (1999) tested patients using this paradigm to obtain an indication of spreading activation patterns. Consistent with previous studies, they found an increased facilitation effect, but no evidence of an enhanced priming effect. They claimed that these results were not consistent with a spreading-activation hypothesis of enhanced priming based on automatic influences. That SP effects usually disappear towards the longer SOA provides a counter-argument for impairments in strategic mechanisms that are used to detect meaningful features of the stimuli. In the Stroop task, this might result in a failure of strategic allocation of attention to attenuate the influence of the word meaning and focus solely on its colour.

Evidence of Enhanced Automatic-Processing

Attempting to form interpretations in favour of either abnormal automatic or controlled processing in schizophrenia is made difficult by discrepancies among SP findings (see Table 3). Spitzer et al. (1993b) modified the SP paradigm to provide unequivocal evidence of spreading activation. They hypothesized that enhanced spreading of activation not only implies 'faster spread' but also 'farther spread' of activation in the semantic network. Far associations instead of close associations should therefore provide a better means of discriminating between hyper-activated association networks and impairments in contextual processing. To test indirect priming they identified common mediators between the prime and target. For example, the word *chalk* and *black* both serve as primes for the word *white* but not with each other. In comparison to the control group, the schizophrenia group showed increases in both direct and indirect priming for both SOAs. A trend towards larger effects at short SOAs was also found among schizophrenics. Spitzer et al. (1994) interpreted these results as providing evidence for both farther and longer automatic activation of semantic networks.

As mentioned, abnormalities in the semantic network have been linked to symptoms of TD in schizophrenia. In by Spitzer et al.'s (1993a) earlier study, TD patients were compared to non-TD patients and normal controls on a normal LDT. In this study, the TD group showed significantly increased direct and indirect SP compared to controls at both long and the short SOAs. No indirect priming effects were found within the control group at any SOA, whereas the TD group showed significant increases at the short SOA as predicted by spreading activation. The TD group showed not only greater SP in comparison to the other three groups but also faster mean RTs for both related and unrelated prime–target pairs (an effect not observed in any other SP study). Priming effects in this study were calculated on 'raw' RTs. Since patients are significantly slower at responding in the non-related trials, they may artifactually show a greater difference between two latency measures and, hence, greater priming effects. Percentage scores have been proposed to be a more accurate measure of priming effects as variance in baselines is taken into account. Indeed, when percentage scores were applied to the above study, effects of SP disappeared.

Table 3. Summary of results of schizophrenia patients on semantic priming (adapted from Minzenberg et al., 2002) and PDP studies.

	Patient Sample	Paradigm; SOA; RP	Effect Direction	Comments
Enhanced Spread of Activation				
Spitzer et al. 1993b	32 inpatients	LDT: 0/700; 67%	↑ n.s. direct/indirect SP both SOAs	No effect when percentages of RTs used
Spitzer et al. 1994	70 inpatients	LDT: 200/400/700; 39%	↑ SP	Groups not directly compared statistically
Henik et al. 1995	16 "chronic"	LDT: 240/1840; 50%	↑ SP	
Kwapil et al.	21 outpatients	WP: 500; 33%	↑ accuracy used degraded targets	
Normal Spread of Activation				
Blum and Freides 1995	20 outpatients	LDT: 350; 33%	→ TD/nonTD SP = control	Only one level of SOA tested
Ober et al. 1995	19 outpatients f SP for	WP/LDT: 250/17%	→ SP with ↑ SP for horizontal pair LDT	vertical vs. horizontal category pairs
Impaired Spread of Activation				
Henik et al. 1992	22 "chronic"	LDT: 240/1840; 50%	↓ SP fewer patients with SP effect at 240	
Ober et al. 1997	31 outpatients	LDT: 260/1000;15%/46%	↓ SP n.s. SP	
Impaired Controlled Processing				
Aloia et al. 1998	20 inpatients	WP: .350; 63%	↓ SP for TD vs. nonTD/controls for highly-related pairs	n.s. SP for TD; no fixed SOA. SP effects expressed as RT percentages.
Barch et al. 1996	100 inpatients	LDT: 950; 50%	↓ SP for TD/nonTD vs. control	n.s SP only for longest SOA. Largest sample.
Ober et al. 1995	19 outpatients	WP/LDT: 250/17%	↓ SP horizontal pair LDT only	vertical vs. horiz. category pairs
PDP Complete Review of Evidence				
Kazes et al. 1999	35 inpatients	WSC: 40 items	↓ R/intact A compared with controls	↑A when baselines adjusted for patients
Linscott et al. 2001	22 outpatients	WSC/LC: 120/140 items	↑ A/↓ R only for WSC	Patients expressed difficult with inhibition
Barch et al. 2004	29 inpatients	Speeded Stroop Task	↑ A/↓ R	Revised opposition procedure used
Barch et al. in press	32 outpatients	Word-Pair Cued Recall	↑ A/↓ R remember/know responses invalid	Control group included 1st degree relatives

Note. LDT: lexical decision task; LC: list discrimination task; WP: word pronunciation task; WSC: word stem completion; SOA: stimulus onset asynchrony; RP: relatedness proportion; RT: reaction time; SP: semantic priming; TD: thought disorder; R: recollection; A: automatic; n.s.: not statistically significant.

Evidence of normal levels of SP is also taken in support of hyper-activation because it represents relatively enhanced effects from generally slower task performances. Ober, Vinogradov and Shenaut (1995) modified the SP paradigm include both 'horizontal' category relationships (e.g. *nickel-dime*) and 'vertical' relationships are by using superordinate word categories (e.g. *bird-robin*). SP effects were found in the schizophrenia group for all conditions except the horizontal LDT. This condition was found to evoke controlled *matching* strategies (reviewed earlier) and as such is more sensitive to post-lexical deficits (processes that operate outside the automatic level of semantic activation that natural use of language depends on; Becker, 1980). While these findings indicate, at the least, intact levels of activation, after a closer analysis of performances the evidences actually suggests impairments of controlled strategies that conceptually relate stimuli.

Evidence of Impairments in Controlled-Processing

In line with a deficit of context-processing, several studies have reported evidence of impairments in strategic processing of SP. Henik, Nissimov, Priel and Umansky, (1995) tested the effects of increased cognitive load on SP through the use of distractor tasks. Visual and auditory distractors were used across two experiments, with attenuated priming found for visual tasks only. It is believed that cross-modal interference - as seen with the visual distractor - implies a single-channel limited resource capacity, as emphasized by Henik and colleagues (1995). SP effects were negligible across both short and long SOAs indicating that even automatic processes require a portion of attentional resources. When the distractors were removed SP effects returned to above normal levels. These findings were interpreted as an impairment of controlled processing: if enhanced automatic processing were present patients should still be able to encode and locate memory traces at this level. Vulnerability to distractors indicated that patients had inadequate attentional capacity to 'tune out' these effects. Henik and colleagues (1995) suggest that elimination of any priming effects in patients arises from the allocation of resources to deficient controlled processing during distraction. The theory of compensation has received evidence from neuroimaging and will be discussed later.

For the claim of stable enhanced SP effects in TD patients, Besche et al. (1997) found contflicting evidence. In two LDT studies with similar conditions, they

found TD participants did not demonstrate a significant SP effect at longer SOAs compared to non-TD patients, psychiatric controls or normal controls. Another study by Aloia and colleagues (1998) used a modified version of the paradigm in Spitzer et al.'s (1994) indirect priming task. High TD and low TD participants were tested using targets that belonged to the categories of *high-relatedness, medium-relatedness* and *low-relatedness* (based on free-recall norms). The high TD group showed no significant SP at any of the three word-relatedness conditions, whereas control and mild TD groups showed significant SP at the high- and medium-relatedness conditions. In contrast to Spitzer et al.'s (1994) finding of spreading activation via indirect priming, none of the three groups exhibited priming at the low-relatedness condition.

Summary of Findings from Semantic Priming

The results from Spitzer's research group are inconclusive with regards to confirming enhanced priming in schizophrenia. This may be due to methodological limitations or heterogeneity of impairments among schizophrenic patients such as TD (Minzenburg et al., 2002). In contrast, the results of studies in which experimental conditions favour controlled processes are relatively consistent. There appears to be converging evidence of impaired SP, particularly in conditions where semantic matching or other post-lexical processes are engaged, such as in LDT (in comparison to WP tasks), or with high-association pairings or "horizontal" category relationships between prime and target. In response to reports of hyperpriming in schizophrenia, Barch and colleagues (1996) have argued that these conclusions are based on unreliable measures of spreading activation. They claim previous findings of enhanced priming have been confounded by the use of inappropriate experimental designs, the effects of longer RTs, and potential effects of medication. One design issue was that most studies that claim enhanced priming use LDT, which appear to be more influenced than WP by strategic mechanisms which may operate even at very short SOAs (Neely, 1991). Similarly, for long SOAs the results cannot be claimed to represent purely controlled executive processing as automatic processes may contaminate responding. In their review of SP in schizophrenia research, Minzenberg and colleagues (2002) conclude that variables of increasing cognitive load and cognitive strategies have the most pronounced effect on the magnitude of SP shown

by patients. This strongly suggests a deficit in the strategic use of attention, although the specific relationship this has with SP remains unclear. In the following section recent evidence of abnormalities in neural networks will be highlighted and explained in light of the type of impairments previously described.

Neural Dysfunction of Schizophrenia

Dysfunction of the dopamine (DA) neurotransmitter system is the foremost finding of brain-imaging studies of schizophrenia (Cohen & Servan-Schreiber 1993). The role of dopamine has been implicated in regulating cognitive control so that context representations can be accessed by conscious awareness. Many of the processes associated with cognitive control have consistently shown activity in the dorsolateral-prefrontal cortex (DLPFC). Specifically, DA is theorized to be involved in regulating the "signal-to-noise" ratio of information within the *controlled* central executive (CE) component of Baddeley and Hitch's (1974) influential model of working memory (WM). This facilitates attenuation of perceived "irrelevant" stimuli so that strategies can focus on task relevant information (Braver, Barch & Cohen, 2002). Studies on component processes of working memory support the distinction of manipulation and maintenance of information within the CE (Owen, 1997; as cited in Barch, 2004), with DLPFC engaged primarily by tasks of manipulation. Recent functional-imaging studies using the N-back task have found differential deficits in manipulation compared to maintenance in schizophrenic participants (Kim et. al, 2004; as cited in Barch, 2005), as evidenced by decreased activation in the DLPFC.

Advances in functional magnetic resonance imaging (fMRI) give increased spatial resolution, allowing for clearer more reliable images of activation. Using fMRI, the pattern of activity in tasks of executive function, thought to depend on processes of cognitive control that typify schizophrenia is a 'hypofrontal' response (Volz et al., 1997). Recent studies have challenged this concept of hypofrontality during tasks of executive functioning. For instance, reduced frontal activity was seen in patients performing a paced verbal fluency task (Curtis et al., 1998), but not during the performance of semantic categorization in which normal prefrontal activity was seen. In fact under certain conditions, individuals with schizophrenia exhibit *hyper*-activation of the PFC (Arcuri & McGuire, 2001). One hypothesis put forward to explain this inconsistency in activity is that there is a different cognitive-load curve in

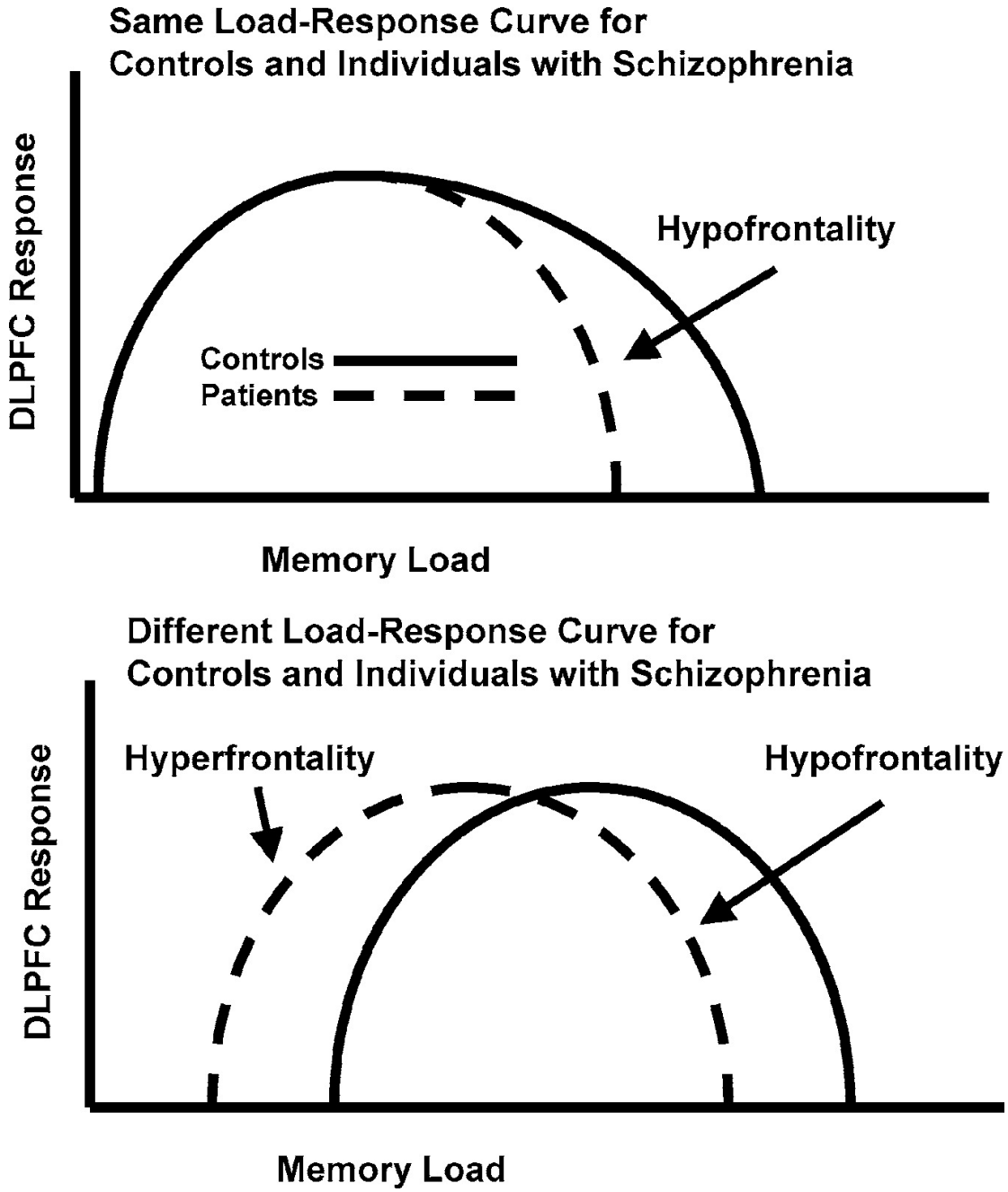

Figure 1. Illustration of alternative load-response curves from Callicott et al. (2003), (as displayed in Barch, 2005). The Y-axis plots hypothetical activation responses in DLPFC; the X-axis plots increased load in working memory. The top panel illustrates the condition in which DLPFC activity drops off at a smaller working memory load for individuals with schizophrenia than for controls, described by Callicott et al. as the same load-response curve for individuals with schizophrenia and controls. The bottom panel illustrates the condition in which DLPFC activity at lower working memory loads is increased in individuals with schizophrenia as compared with controls, but at higher working memory loads is decreased in individuals with schizophrenia as compared with controls

schizophrenia. It is known that PFC activation increases with demand until capacity is exceeded, at which point a sharp drop in activity is seen. Callicott et al. (2000, 2003) suggest two possible scenarios (*1*) the load-activity curve may be the same, but WM capacity may be lower, leading to a drop-off in DLPFC activity at memory loads lower than those of controls; or (*2*) the load-response curve may be different, such that patients show greater DLPFC activity than do controls at lower memory loads (referred to as inefficient DLPFC activity), but show less DLPFC activity than do controls at higher memory loads. Figure 2 provides a visual representation of the hypothesized load-response drop-off scenarios. The hyperfrontal hypothesis of varying load-response is compatible with a long line of schizophrenia research that hypothesizes a focal deficit of 'consciousness' that dates back three decades: "The symptoms of schizophrenia can be interpreted as the result of a defect in the mechanism that controls and limits the contents of consciousness." (Frith, 1992, p. 116).

Converging evidence for the dysfunction of consciousness theory comes from findings suggesting that apparent 'decreased' activation may actually reflect higher resting activities in these regions (Gusnard & Raichle, 2001), in addition to the evidence of controlled processing impairments in SP. Another important feature of pathophysiology in schizophrenia has been described using innovative designs of functional imaging. Functional connectivity assesses the relationship between multiple brain regions by making a priori predictions of correlated activity (Friston, 1997). From this perspective impaired cognition arises from the failure of integration more than local abnormalities. This method has implicated disconnectivity in the fronto-temporal pathway thought to underlie EM (Fletcher et al., 1995). For instance, PET studies have demonstrated a decrease in temporal lobe activity during tasks that engage the frontal cortex (Lawrie et al., 2002). Specifically, several studies together suggest abnormal phasic dopamine bursts generated by subcortical systems disrupt the synthesis of information from frontal connections to the hippocampal formation (Meyer-Lindenberg, 2005; Braver, Barch & Cohen, 2002; Fletcher et al., 1999), which are considered crucial to the binding of novel information (Eichenbaum & Cohen, 2001). In summary, schizophrenia represents a collection of complex and interactive neural dysfunctions on local, integrative and connective dimensions. Despite huge uncertainty into neural pathways of cognitive impairments, there is clear evidence for abnormalities in systems underlying relational binding, memory and executive function.

Aims of the Present Study

The investigation of cognitive impairment in schizophrenia has been hampered by paradigms that fail to provide 'pure' estimates of automatic and controlled influences. Jacoby's (1993) PDP provides a way to overcome this problem. These influences have particularly relevance to cognitive impairments in schizophrenia. A body of research points towards a select deficit in the controlled use of semantic elaboration of stimuli to enhance encoding and improve memory retrieval. The failure to find fully convergent evidence for a explanatory theory may be due to a stumbling block within this research of how the conditions of automatic and controlled uses of cognition are defined. The PDP has huge applicability to these studies and may provide a much needed new approach to the study of cognitive impairments in schizophrenia, as well as how dissociations of impairments might influence models of healthy cognition. Its relevance to semantic use of knowledge can be seen in the following study.

Jacoby (2003) extended the PDP's design to separate strategic and automatic influences of contextual association on recollection. Instead of word-stems, word-pairs were used that were either associatively connected to each other or not at all, with a similar opposition procedure as used previously (i.e., using inclusion/exclusion tasks). The results of the exclusion task - where subjects were encouraged to produce words outside of the study list - showed that contextual relatedness improved recollection. In contrast, for automatic influences word-pairs from related pairs were more likely to be given as a response than were new words under divided attention. The increased probability cannot be a product of strategic processing because these influences would have had the opposite effect on performance. The findings confirm that the strength of the cue presented at test was increased with associative relatedness, improving retrieval. Reinstating associative context differentially affected influences of automatic and controlled processes of episodic memory, making it a crucial consideration for the research on SP in schizophrenia.

To our knowledge, three studies have used the process dissociation procedure to examine automatic and controlled impairments in schizophrenia patients to date (for a summary see Table 4). Linscott and Knight (2001) reported lower estimates of conscious recollection in patients than in controls and greater influence of familiarity associated with TD. However, this effect was only seen in performances of a word-stem completion task and not for a list discrimination task. The opposition task they used required the patients to inhibit old word responding and produce new words.

However, studies of responding biases in schizophrenia show that they may exhibit dysexecutive responding, with fast uninhibited decisions made based on less information and rated with high confidence than normal (known as a 'jumping-to-conclusions' bias; Woodward, Buchy, Moritz & Liotti, 2007). An effect of this might have been that despite full recollection of a word, the patient failed to adhere to the instructions due to the impulsion to produce the studied word. In fact, the authors reported difficulties in getting patients to maintain and apply the task relevant information for correct responding and were even required to modify the task so it was less demanding.

Barch and Jacoby (in press) used a technique developed by Jacoby and Hay (1999) to avoid the problems inherent in the opposition technique by negating the need for an "exclusion" condition, opting instead for a frequency bias, whereby automatic responding of a frequently presented word was conflicting with recollection of a less presented target word. They replicated these finding of lower recollection estimates and enhanced familiarity processing at retrieval in schizophrenia. They argue that since evidence shows that recollection and familiarity processes can be independently manipulated, a change in one does not entail a reciprocal change in the other, and therefore it is unlikely that these findings represent an artefact of disengaging recollection. Contrary to these findings of enhanced automatic influences, Kazes et al. (1999) found impairments in recollection processes in patients compared to control subjects, but no differences for familiarity across groups, consistent with the context-processing deficit hypothesis. The word stem completion task was used again here, rendering estimates of recollection open to confound from response biases. Linscott and colleagues (2001) also note that estimates of automatic processing were not adjusted for lower baselines by patients. Adjusting them actually resulted in estimates that favour hyperautomatic activation.

To the best of our knowledge, no study to date has used the PDP to investigate the use of contextual associations on recollection in schizophrenia. There appears to be a trend in the above studies for enhanced familiarity, but this does not disconfirm the context-processing deficit hypothesis as lower recollection estimates have been found in all cases. While these processes are independently influenced by different inputs, they may also be part of a limited capacity system that allocates available resources from impaired to intact processes. Jacoby (2003) demonstrated this by showing that artificially disabling recollection by dividing attention enhanced the influence of contextual association on familiarity. Therefore, significant increases in

familiarity in the presence of low recollection must not be misinterpreted as enhanced processing. Therefore, supportive evidence of hyper-activation must show that semantic relatedness significantly enhances familiarity in schizophrenia with a simultaneous improvement in recollection under full attention.

The aim of this study is to provide a new approach to test the context-processing deficit hypothesis of schizophrenia. We will do this by testing the claims of impaired recollection and strategic use of context. The paradigm used here is a modified version of the one used by Barch and Jacoby (in press). In their experiment, word-pairs of equal or near associative strengths were chosen. Here, strength of association was manipulated into *high* and *low* association conditions. Varying association was chosen instead of *related* and *unrelated* (as with Jacoby, 2003), because by not eliminated associative context, we were manipulating but not completely disengaging strategic recollection. Therefore, accuracy of remembering low association word-pairs would be a strong measure of recollection as further elaboration is required. To support the hypothesis, we predict that: (1) high associative strength should improve word-pair recollection significantly in both groups, but benefit patients significantly more due to increase in estimates of recollection by promoting a semantic connection between words (2) patients should perform significantly worse than participants at low levels of associations, driven by lower estimates of recollection (3) Estimates of familiarity at low association should be equal to or significantly higher than healthy participants, due to the effect of reducing the potential for strategic processing on familiarity described above. To further analyse the dissociation of contextual control on the estimates of recollection and familiarity, a LOP condition was added which required participants to make either conceptual or superficial judgements on word-pairs. It is predicted that deep processing will benefit both groups to a similar extent, but boost recollection in the patient group significantly more by presenting them with useful encoding strategies they would otherwise be unable to express. This prediction is based on the findings that orientation towards deep encoding can greatly improve recollection in individuals with schizophrenia from poor baselines, but top-down conceptual encoding selectively improves recollection and has less effect on familiarity.

Unlike Barch and Jacoby (in press), it was decided to omit the remember/know paradigm. Two reasons were given for this; firstly, as mentioned, individuals with schizophrenia are highly biased in judgements, especially concerning level of confidence and thus, feelings of familiarity responses might be upgrade to a

definite experience recollection; secondly, as Barch and Jacoby note from their results, subjective awareness states do not correspond with objective memory estimates in patients with schizophrenia. They did not find reduced remember responses in any condition for patients and actually observed increased remember responses in 'guess' trials where no event was available to recollect, indicating that a bias might indeed be present. Kazes et al. (1999) make a noteworthy point about the mapping of memorial states of awareness onto memory processes. They argue that fundamental differences between volitional searches of memory and awareness state might be orthogonal: conscious awareness of episodic memory may arise from processes other than the controlled use of memory to induce recollection. Background neuropsychological measures of episodic and semantic memory were correlated with the results of the PDP to distinguish effects of individual differences and base-line levels of ability between groups.

Methods

1.1 Participants

Participants with schizophrenia (15 males and 5 females) were outpatients recruited from the Health Service Executive funded (Ireland) Adult Mental Health Services in Ennis, Co. Clare. The service users were primarily low-care level living in community based accommodation. Individuals were all diagnosed with DSM-IV schizophrenia. Control subjects (8 males and 12 females) were recruited from the same locality by personal contact according to age suitability and received monetary reimbursement for participation (€8 per/hour). Exclusionary criteria for controls included: (a) being above 55 years old (due to possible effects of cognitive decline) (b) a lifetime history of any Axis I psychiatric disorder or any first-degree relative with a psychotic disorder (c) a positive rating on the Prodromal Questionnaire (PQ; Loewry, Bearden, Johnson, Raine & Cannon, 2005) which is a non-clinical self-report measure used to detect schizophrenia, schizoaffective disorder, schizoid personality disorder and risk for future onset of psychosis. For participation in the patient group, the following exclusionary criteria applied: (a) showing a positive diagnosis for substance abuse (at time of testing), intellectual disability, traumatic brain-injury or any other comorbid condition that might confound assessment of psychiatric diagnosis; (b) actively on a prescription of benzodiazepines which might induce slower cognitive responding.

Participants with schizophrenia were stabilized on anti-psychotic medication and attended regular therapy sessions. Diagnoses for all participant groups were determined using the Structured Clinical Interview for DSM-IV (SCID-IV), conducted by doctorate level clinical psychologists. Dimensional assessments of psychopathology for all participants were rated using the Scale for the Assessment of Negative Symptoms (SANS), Scale for the Assessment of Positive Symptoms (SAPS). The patient group comprised a representative cross-section of schizophrenia disorder in both type and severity. Most patients belonged to the positive symptom cluster, defined by the total scores for hallucinations and delusions on the SAPS, and unusual thought content, suspiciousness, grandiosity, and perceptual abnormalities on the SIPS. Four (20%) of the patients exhibited predominantly negative symptoms, qualified by the total scores for affective flattening, alogia, anhedonia, avolition, and attention on SANS, and social isolation, avolition, decreased expression of emotion, decreased experience of self, decreased ideational richness, and deterioration in role functioning on the SIPS. The remaining patients had a positive symptom profile in accordance with the disorganization symptom cluster which included the total scores for formal thought disorder and bizarre behavior on the SAPS, and disorganized communication, odd behavior, bizarre thinking, trouble with attention, and personal hygiene on the SIPS. Only 4 patients (20%) exhibited TD at time of study, with 18 (90%) having a pretreatment diagnosis of TD and receiving long-term neuroleptic treatment. A further 8 (40%) were on antichlorinergic drugs and 2 (10%) were receiving no treatment.

1.2 Procedures

Episodic Memory Task

The test items for the PDP were presented on a laptop using E-Prime Studio 2.0. For this task, participants were presented with pairs of words in a training phase. The word-pairs had two possible combinations (e.g., judge-just, judge-jury) with one pairing presented more frequently than another during this phase. A trial consisted of the presentation of a single word-pair presented on the computer screen for 1.5 seconds. The word-pair was immediately presented again on the computer screen, but two of the letters from the second word were missing (e.g., judge - j u _ _). The participants were instructed to complete the word-pair aloud using the immediately presented word-pair. We asked individuals to generate the word-pair as well as read it so that the frequency bias could be enhanced by a generation effect. There were 14

sets of two word-pairs and one pair from a set was presented on each trial during the training phase. One word-pair from every set was sampled in a block of 10 trials, and 10 blocks were completed during the training phase for a total of 140 trials. The sets of word-pairs were selected from the norms reported by Jacoby (1996) with the criteria that the difference in associative strength of the two possible word combinations must be at least 0.8 according to base-rate free recall as reported by the South Florida Free Association Norms (Nelson, McEvoy & Schreiber, 1998). The frequency bias was established by presenting one pair (e.g., judge-just) 7/10 times and the other pair 3/10 times (e.g., judge-jury). The pair presented more frequently during training was counterbalanced across participants and high/low word association. Thus, following the training phase, one word-pair should be more familiar or have higher accessibility bias then the other word-pair.

After the training phase and establishment of a 'habit', participants were presented with 10 sets of study and test blocks. In each study block, participants were presented with 13 of the word-pairs presented during the training phase (e.g., either judge-jury or judge-just). During a study block, word-pairs were presented one at a time the computer screen for 2 seconds with a .5 second inter-trial interval. On half the study trials (trials 1-3 and 6-7), participants were instructed to perform one of two judgments for the LOP manipulation. For the shallow condition participants were asked to verify if the first letter of the first word and the last letter of the last word were in alphabetical order (e.g., 'j' in judge and 'y' in jury, which would require a yes response to verify the alphabetical order of j and y). In the deep condition participants were asked to use the two words in a meaningful sentence (e.g., "the jury gave the verdict to the judge"). Allowing participants to construct their own sentences had the advantage over conventional abstract/concreteness deep processing tasks of being able to exploit the meaning of the words in a way that was defined by their own unique, preexperimental learning history. Also, the shallow task was purposefully made more complicated than usual upper or lower case shallow judgment tasks to ensure that 'depth' of processing represented a qualitative difference in encoding type and not just a reflection of effort expended (for a critique of the LOP paradigm see Baddeley, 1978). Instructions for the LOP task were presented during every trial and were colour coded to signal type (red for deep; blue for shallow). Then, participants were presented with a short distracter task where numbers appeared in the center of the screen and participants had to count down with them from 6 to 1.

Participants were then given a cued recall test on the items presented in the immediately preceding study block. At test, items were presented with a word-pair with 2 to 3 of the letters form the second word missing (e.g., judge – j u _ _). Participants were instructed to complete the word-pair using the word-pair studied in the immediately preceding study session. To maintain the familiarity bias created during the training phase across the 10-study/test blocks, the frequency of word-pair presentation during the study/test blocks was also asymmetric. The word-pairs from each set that were the ones presented most frequently during training were studied on 6/10 blocks. The word-pairs that were ones presented less frequently during training were studied on 3/10 blocks. During each study block, only 9/10 word-pairs set were used and one word-pair set was not presented. However, in each test block, all 14 word-pairs were tested, thus testing participants on one word-pair not studied during the preceding study block. On these "guess" trials (n = 10: 7%), only familiarity can drive a response, allowing us to examine whether the familiarity manipulation was equally effective across groups. There were two additional types of trials at test. On congruent trials (n = 88: 63%), the word-pair included in the study block was the same as the word-pair presented more frequently during training. On these trials, both habit and recollection can contribute to a correct response. On incongruent trials (n =

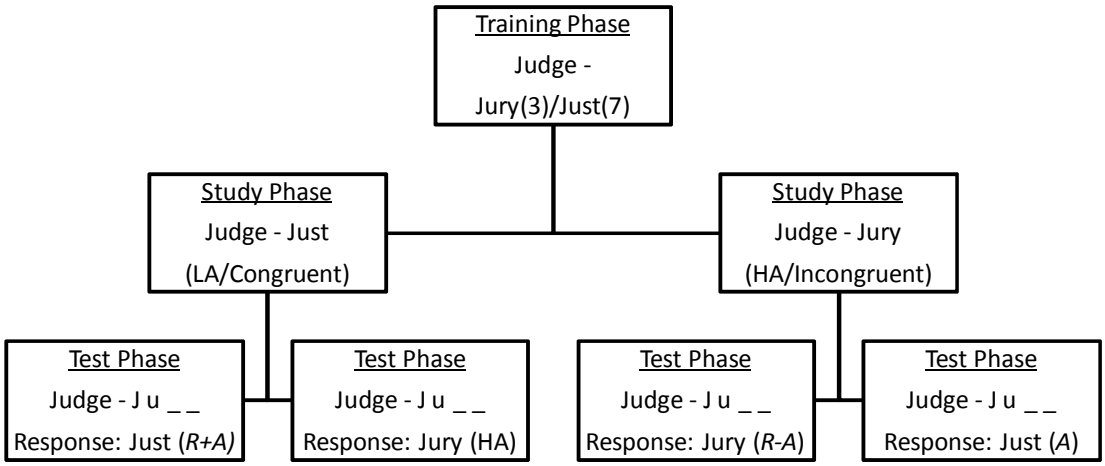

Figure 2. Illustrative example of session for single item in the high/low association and congruent/incongruent conditions of the PDP version used (LOP task not shown). *Note*. In training phase, brackets contain frequency of presentation. In study phase, brackets contain condition-item type. In test phase, brackets contain assumed processes driving responding; LA: Low association; HA: High association; R: Recollection; A: Automatic influences.

42: 30%), the word-pair presented in the study block was the less frequently presented word-pair. On these trials, habit and recollection work in opposition to each other, and only recollection can lead to the correct response. Provided below in Figure 3 is an illustration of the different conditions and assumed processes underlying responding.

Neuropsychological Background Measures

To examine the relationship of contextual processing and process estimates to neuropsychological measure of EM and executive function, we assessed performance on three measures of cognitive ability. These measures included: (a) The California Verbal Learning Test 2nd Edition (CVLT-II; Delis, Kramer, Kaplan & Ober, 2000): a measure of immediate recall of EM and ability to categorize words to enhance learning (indicated by score of semantic clustering); (b) Hayling Sentence Completion Task (SCT; Burgess & Shallice, 1997): assesses the patient's frontal lobe dysfunction via measures of inhibition and response time; (c) Vocabulary and Matrices Reasoning subtests of the Weschler Abbreviated Scale of Intelligence (WASI; Weschler, 1999): provides a partial scale high reliability estimate of participant IQ (intelligence quotient). Background measure data was missing for two controls and one patient for reasons unrelated to performance or storage methods.

1.3 Data Analysis

The probability of responding with a "familiar" word on the congruent (CON) trials can be expressed as the probability of recollection (R), plus the probability of the word 'automatically' (F) coming to mind in the absence of awareness. This can be stated formally as: probability (CON) = R + F(1-R). For the incongruent condition (INC) a studied word will only be produced if recollection can attenuate the effects of familiarity that are driving incorrect, habit driven responding. The likelihood of producing an incorrect, but familiar response on incongruent trials can be formulated as: incongruent: probability (INC) = F(1-R). Thus, one can derive the process dissociation estimates for recollection as R = CON – INC or R = [prob(correct/congruent) – prob(incorrect/incongruent)], and the process dissociation estimate for familiarity as F = INC/(1-R) (Hay & Jacoby, 1996; Hay & Jacoby, 1999; Jacoby et al., 2001).

1.4 Statistical Analysis

Patients with schizophrenia and normal participants were compared with one-way analyses of variance (ANOVAs) for differences in episodic memory on raw accuracy scores and on estimates from the PDP. One-way ANOVAs were used to locate the significant effects in interactions Independent *t*-tests were used to detect overall between group differences at individual levels of within group factors, such as effects of LOP depth. All significant differences were set at $p < .05$. Bonferroni adjustments were used to control for family-wise error. The use of ANOVAs for the analysis of proportional/categorical data, as is the case here, has recently been criticised for violating certain assumptions of general linear models in its ability to account for random subject and item effects (Jaeger, 2008). However, since previous research has employed this method it is appropriate to use it here for comparative reasons.

Results

2.1Analysis of EM Accuracy

To confirm the finding of impaired EM in schizophrenia, the first analysis examined a group comparison of percentage scores of correct answers only using an independent sample *t*-test. Healthy participants on average scored more highly on total accuracy ($M = .688$, $SE = .019$) than patients ($M = .58$, $SE = .49$), $t(38) = 4.584$,

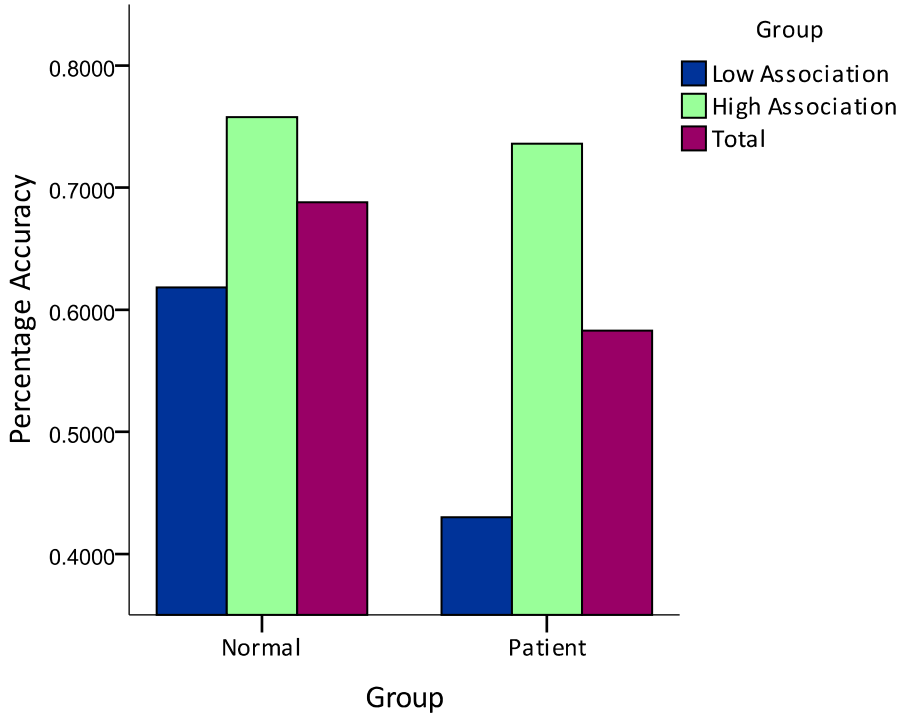

Figure 3. Mean of total percentage accuracy across groups (error bars = +/- 2 SD).

two-tailed $p<.01$, $r = 0.596$ (see Figure 2). The effect size suggests a medium sized drop in overall poorer memory performance from normal levels. All other comparisons at levels of congruency and association were reported as significant at a $p<0.05$ level, with the exception of high association [$F(1, 38<1]$. This implies that under high associative word strength, patients' performances could be improved to the levels of the non-patient group. However, as mentioned previously, the three independent variables of 'Congruency', 'Association' and 'Depth-of-processing' were distributed evenly across trials and therefore any interaction between conditions could have introduced possible confounds to measures of total accuracy.

To isolate individual effects on the dependent variable of accuracy, a repeated measures ANOVA was conducted with levels of congruency and association as within groups factors and with group as a between fixed factor. Only the proportion of data that did not include a LOP condition was used to minimise any confounding effects of interactions. A significant effect for Association was found between groups [$F(1, 30) = 11.557$, $p<.01$]. The results plotted in Figure 3, shows this to be a result of the significantly greater effect of Association on patients than on healthy participants. Main effects were found at the .1% alpha level for Congruency [$F(1, 30) = 22.413$, $p<.01$] and Association [$F(1, 30) = 35.181$, $p<.01$], with group interactions for both

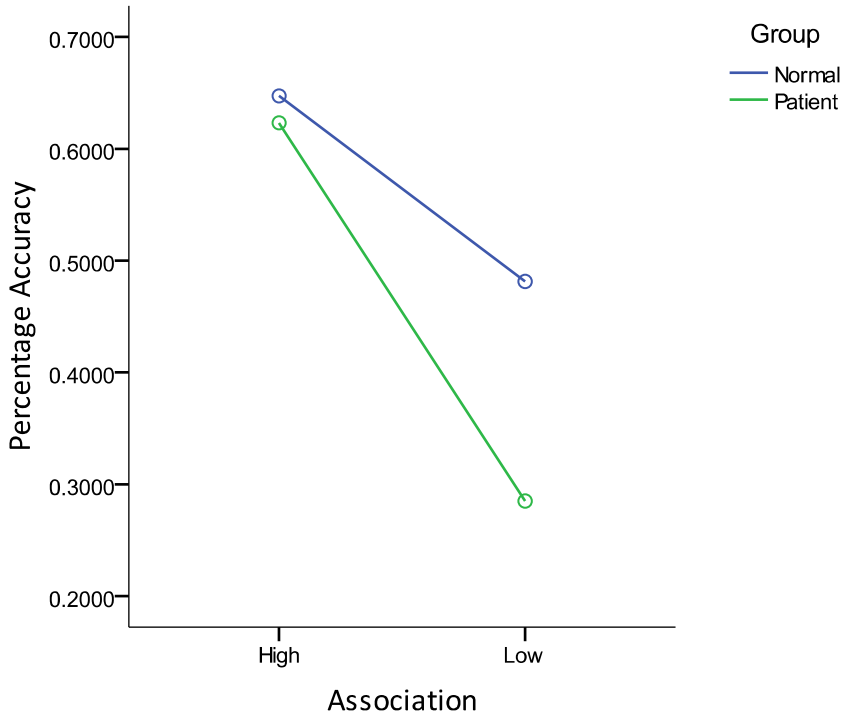

Figure 4. Mean proportion of correct responding in the Association condition across groups.

(see table 4 for a summary of results). Planned contrasts to follow up on these interactions indicate that they represent a higher rate of improvement from significantly less accurate responding for lower levels of both Congruency [$F(1, 19) = 5.148$, $p<.01$] and Association [$F(1, 19) = 10.522$, $p<.01$] in the patient group compared to controls.

For word-pairs of lower associative strength, the memory of patients suffered heavily with an average accuracy drop of 41.45% on incongruent trials. Combining this with the above results imply that while patients were performing significantly lower at baseline levels of association and congruency, they were able to benefit from manipulations designed to facilitate higher accuracy, bringing their responding to almost normal levels. Without a prediction of outcome, we decided to express estimates in terms of the ratios of their influences to see if there was any significance of the proportion in which they were driving responding. This was based on the logic that processes can act in concert and encourage incorrect responses, depending in their relative influence. The estimate ratios within a condition were calculated using the formula [$\sqrt{(\text{PDP estimate X})^2}/(\sqrt{(\text{PDP estimate X})^2}+ \sqrt{(\text{PDP estimate Y})^2})$]. Independent-samples *t*-tests were then used to detect between group differences in estimate ratios. A significant difference was found for low association word-pairs, with patients having a higher ratio of familiarity ($M = .11$, $SE = .04$) to recollection, $t(38) = 2.72$, two-tailed $p<.05$, $r = 0.426$.

Table 4. Analysis of variance summary table of accuracy across conditions and interactions.

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	*F*-ratio
Congruency	.711	1	.711	22.413**
Congruency*Group	.398	1	.398	12.532**
Error (congruency)	.984	30	.032	
Association	1.306	1	1.306	35.181**
Association*Group	.429	1	.429	11.557**
Error (association)	1.151	30	.037	

* Significant at 5% level.
** Significant at 1% level

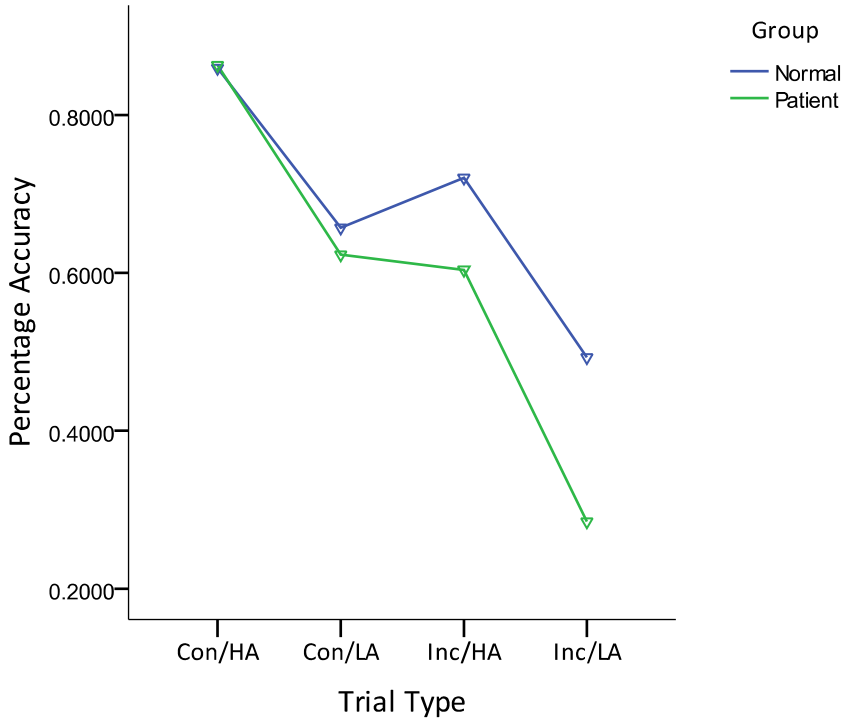

Figure 5. Interaction of congruency and association between groups. *Note:* Con: congruent; Inc: incongruent; HA: high association; LA: low association.

We next tested whether the presence of the LOP paradigm introduced unexpected interaction effects that differed significantly from trials without the LOP task. The within-groups factor of LOP condition with two levels (present or absent) was added to the above repeated measures ANOVA. No significant effect of LOP presence was found within groups [$F(1, 19)<1$]. There was also no difference reported for the presence of LOP between groups [$F(1, 19) = 2.931$, $p>.05$], indicating that LOP trial presence had a similar effect on both groups' overall memory accuracy. An interaction effect was found for LOP presence and association [$F(1, 19) = 2.931$, $p<.05$], which contrasts revealed was due to significantly lower accuracy of patients in trials with no LOP task and with low association word-pairs [$F(1, 32) = 5.146$, $p<.01$], which was probably a result of little or no encoding effort, whereas at least a shallow depth of processing was ensured with LOP.

The LOP portion of the data was then analysed, with depth as an additional within factor at levels of 'Deep' and 'Shallow'. There was a main effect for depth reported [$F(1, 38) = 50.566$, $p<.01$], with no between groups differences in responding to deep or shallow conditions. In accordance with our prediction, both groups benefited from deeper processing to an equivalent extent (see Figure 4).

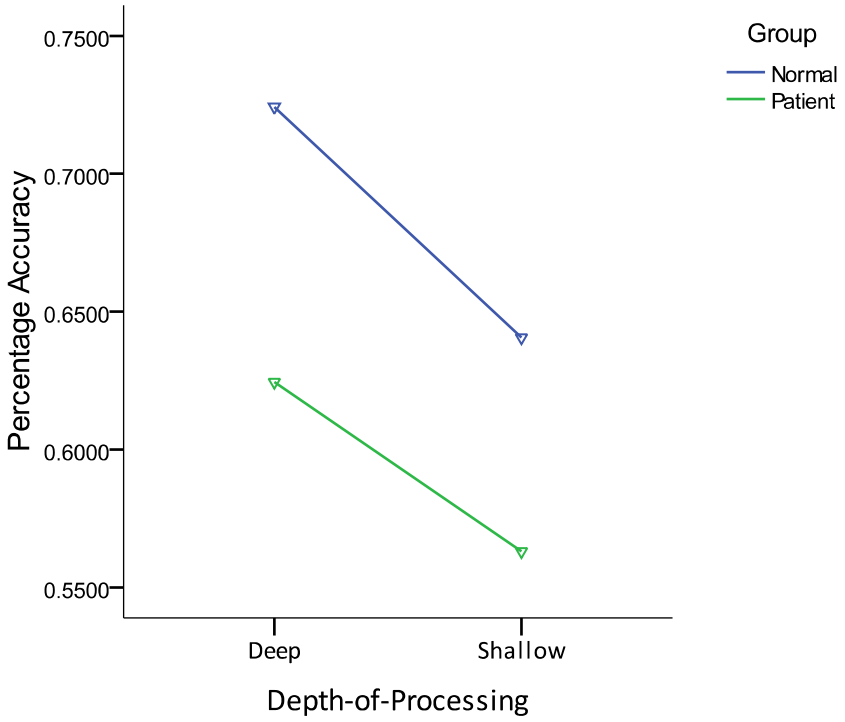

Figure 6. Effect of processing depth on percentage accuracy across groups.

2.2 Analysis of PDP Estimates

To test the main hypothesis, we derived and examined the PDP estimates to observe what change could be seen across conditions and groups. Firstly, a two-way ANOVA was conducted to detect whether there were differences between overall automatic and strategic influences between groups. A significant difference of recollection was found [$F(1, 38) = 21.05$, $p<.01$], which from our examination of the means, appears to reflect a reduction in estimates of overall recollection for patients when compared to healthy participants (see Table 6). A repeated measures ANOVA examining estimates across levels of Congruency and Association identified a three-way interaction between groups' process estimates and levels of Association [$F(1, 38) = 14.091$, $p<.01$]. A series of one-way ANOVA indicated that this interaction represented a significant increases in recollection with higher association, [$F(1, 38) = 25.663$, $p<.01$], with no significant differences for familiarity, [$F(1, 38)<1$]. The finding of increased recollection in individuals with schizophrenia was supported by contextual association supports our hypothesis that failures of episodic memory in schizophrenia arise from a deficit in strategic processes at encoding. We also examined relative increases in process estimates between the groups using an independent samples *t*-test between groups. A significant increase in recollection of patients was reported, $t(38) = 4.399$, two-tailed $p<.01$, $r = 0.58$. As there was no

significant difference in strategic influences at high association, we might infer that since patients had significantly lower estimates of familiarity at low association, they experienced a greater increase in automatic influences to attain normal levels, as shown in Figure 5.

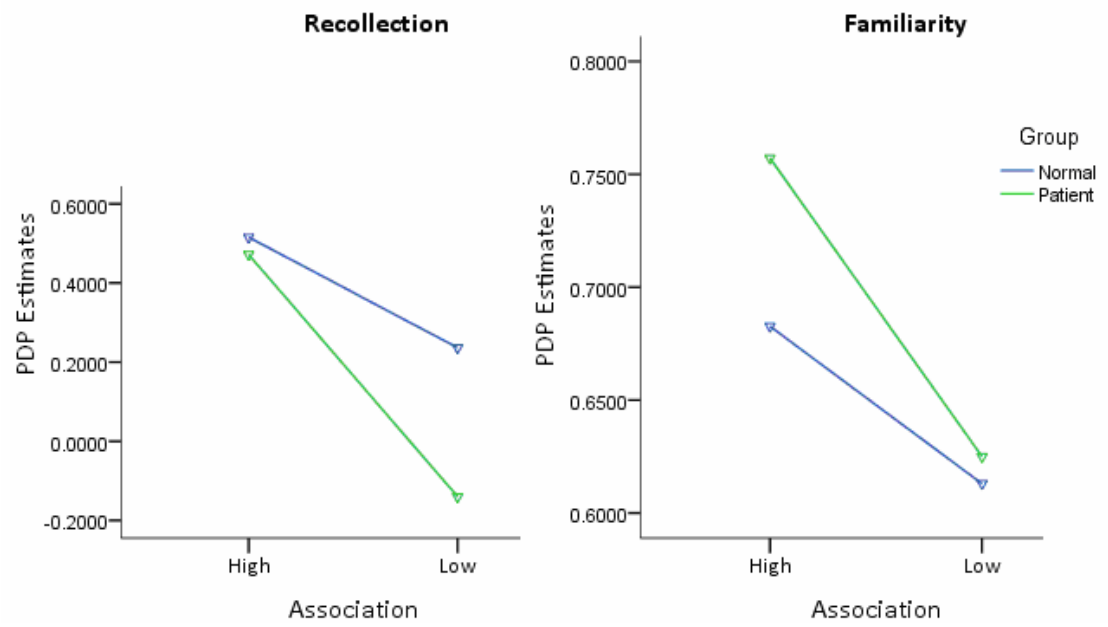

Figure 7. Differences of PDP estimates between groups at each level of association and with separate plots for recollection/familiarity.

For word-pairs of lower associative strength, the memory of patients suffered heavily with an average accuracy drop of 41.45% on incongruent trials. Combining this with the above results imply that while patients were performing significantly lower at baseline levels of association and congruency, they were able to benefit from manipulations designed to facilitate higher accuracy, bringing their responding to almost normal levels. Without a prediction of outcome, we decided to express estimates in terms of the ratios of their influences to see if there was any significance of the proportion in which they were driving responding. This was based on the logic that processes can act in concert and encourage incorrect responses, depending in their relative influence. The estimate ratios within a condition were calculated using the formula [$\sqrt{(\text{PDP estimate X})^2}/(\sqrt{(\text{PDP estimate X})^2}+ \sqrt{(\text{PDP estimate Y})^2}$)]. Independent-samples *t*-tests were then used to detect between group differences in estimate ratios. A significant difference was found for low association word-pairs, with patients having a higher ratio of familiarity (M = .11, SE = .04) to recollection, $t(38) = 2.72$, two-tailed $p<.05$, $r = 0.426$.

Table 5. Groups estimates of recollection (*R*) and automatic influences (*A*) at high/low association.

Condition	Group	Estimates	
		R	*A*
High Association	Healthy	.515	.683
	Patient	.472	.757
Low Association	Healthy	.236	.612
	Patient	-.139*	.625
Total	Healthy	.376	.637
	Patient	.166*	.664

* Significant difference between groups at p<0.001

For the LOP condition, a repeated measures ANOVA was conducted within all conditions and between groups (only on trials with LOP), revealing an effect of depth on process estimates [$F(1, 38) = 6.86$, $p<.05$], such that recollection estimates for both groups were significantly lower at shallow processing than at deep processing [$t(39) = 3.66$, two-tailed $p<.01$, $r = .506$]. There was no difference between groups on recollection estimates for deeper processing, which was inconsistent with predictions. Presence of the LOP condition actually appeared to attenuate the differential effect of association on process estimates between groups, increasing the similarity of process patterns between patients and healthy participants to non-significance [$F(1, 35) = 3.965$, $p>.05$]. This may have been due to the inter-trial delay due to the presence of the additional condition which might have caused the association enhanced memory traces to decay over time.

To examine the effect of the familiarity bias, we used independent *t*-tests to examine the 'guess' trial response data. No significance differences were found for either high association ($t(38) = -.826$, two-tailed $p>0.5$) or congruent responses ($t(38) = .528$, two-tailed $p>0.5$). Both groups appear to have been affected by the familiarity bias and higher association to a similar extent. The mean for both groups were above the levels expected by chance (i.e. 0.5) for both Congruency ($M = .66$, $SE = .18$) and Association ($M = .64$, $SE = .13$)

2.3 Analysis of Neuropsychological Measures

Neuropsychological measures were analysed using a series of one-way ANOVAs to see if any differences in standardized clinical assessments existed between groups. Demographic and clinical information for the participants groups is

Table 6. Summary of Demographic neuropsychological information for participant groups.

Characteristics	Patient (n =20)		Healthy (n=20)		
	M	*SD*	*M*	*SD*	$F(1, 38)$
Age (years)	35.7	11	35.1	9.2	.029
Education (years)	5.2	2.5	9	2	28.14**
WASI-Vocabulary	60.4	11.7	66.6	6.2	7.61*
WASI-Matrices	22.9	6.4	29.1	1.9	20.47**
CVLT-memory	8.8	2.4	14.9	1.4	62.73**
CVLT-learning	1.3	1.6	5.4	3.2	18.76**
Hayling Time	6.7	1.6	6.1	1.8	3.96
Hayling Score	5.6	2.1	4.4	1.9	5.31*

* Significant at 5% level
** Significant at 1% level

shown in Table 6. Differences were reported on all measures with the exception of the time component of the Hayling SCT. However, patients scored significantly lower on the score component, a measure of a person's ability to inhibit primed responses. In addition to indicating an inhibition deficit, this finding could also imply a contextual processing deficit, as unconnected responses require that correct associations are easily accessible so they can be actively avoided. The finding of wide-spread impairment suggests that psychiatric diagnosis was a decisive predictor of cognitive impairment between groups.

Discussion

Consistent with the context-processing deficit hypothesis of memory impairments in schizophrenia, the current results provide clear evidence of the impaired ability to use strategic processing to support the recollection of episodic memory. Contrary to the small body of research that have used the PDP on samples of individuals with schizophrenia, an interpretation of enhanced familiarity was not supported. The results also replicated the findings of Ragland and colleagues (2003), with patients improving at the same rate as healthy participants when semantic-organisational strategies were made more accessible. Further, we also found evidence that strategic use of context was only impaired beyond a certain point of required elaboration.

Neurocognitive impairments in schizophrenia have become the focus of a growing body of research dedicated to explaining the pathways between neural dysfunction and symptoms of schizophrenia. There is a growing trend in the research towards a reduction in the use of recollection processes during EM among individuals with schizophrenia (Danion et al., 1999, Brébion et al., 2006, Barch et al., in press). Like amnesiacs, individuals with schizophrenia appear to be selectively impaired in how they consciously attempt to retrieve a specific event, while implicit feelings and effects of familiarity remain intact. Unlike amnesiacs, however, they appear to be able to improve their episodic memory when provided with the means of developing cues for prospective recall (Brébion, Amador, Smith, & Gorman, 1997; Huron et al., 2003). Evidence in line with this finding comes from studies using a wide-range of methodologies and approaches. We have reviewed some of the evidence from SP and Stroop tasks, but many studies using other approaches not discussed here, such as latent inhibition and error-detection, have arrived at a similar conclusion of a feature binding deficit (Escobar, Oberling & Miller, 2002; Fletcher, McKenna, Friston & Frith, 1999).

At present, the two leading explanations for the EM impairment in schizophrenia are the spreading activation and context-processing deficit hypotheses. They both propose abnormal functioning of a specific memory process is the cause of the impairment, with the former in favor of enhanced familiarity and the latter supporting reduced recollection. The present study developed a procedure to produce dissociable patterns of responding from the predictions of these theories. The results were in line with performances as predicted by a failure to strategically enhance recollection through the use of contextual cues. The first scenario tested was of improving memory accuracy by increasing contextual association between words in a word-pair. This occurred with a simultaneously dramatic increase in contributions from recollection from low to normal levels for individuals with schizophrenia, thought to be driving the enhanced performance. This finding is inconsistent with the spreading activation theory, which would have predicted an increase of familiarity. However, familiarity did increase more for the patient group than the control group, but such an increase is insignificant and expected by the proportionally larger increase in recollection (Jacoby, 2003).

A strong prediction of spreading activation would have been normal to enhanced responding of the low association condition, based on the evidence of farther reaching spread of activation in the semantic network of schizophrenics

(Spitzer et al., 1993). No such effect was reported, with low association actually found to significantly decrease memory accuracy in the patient group. Instead, evidence for lower recollection estimates was observed, with the most profound effect found on PDP estimates being that of low association on recollection. The next most dramatic effect was the increase of recollection with higher association to normal levels. These findings together might suggest that context-processing is itself intact, but with an easily exceeded capacity of required elaboration. Higher association increases the proximity of words in the semantic network, making salient the nature of their relationship that could be used to facilitate recollection. As mentioned, these higher levels of contextual detail improve recollection by making the perceived memory trace more distinguishable (Rajaram, 1996) and easier to discriminate from and inhibit the intrusion of other related memories. This finding is consistent with the differential cognitive-load theory of prefrontal activity (Callicott et al., 2003). At low levels of cognitive load - as facilitated by high association - higher-level semantic organisation strategies were intact and made the normal performance for schizophrenic individuals possible. But the higher load required by further elaboration caused a sharp drop off in the influence of controlled processing on responding, with estimates of recollection in the negative (i.e., producing incorrect responses). The higher than normal rate of increase in recollection of patients also indicates greater controlled responding at this lower load, as would be predicted by the hyperfrontal activation baseline proposed by Callicott and colleagues (2003)

Some findings indicate degrees of enhanced familiarity, but they require careful interpretation. The effect of congruent trials was proven to enhance familiarity based responding. Individuals with schizophrenia appeared to be more susceptible to this effect. However, the rate of improvement was similar to that from higher association. A hyper-activated network would expect the familiarity specific manipulation to cause a stronger increase than variables aimed at improving recollection. Unfortunately, since congruent and incongruent trials are offset in the formulae used to derive PDP estimates, their individual effects on processes of recollection and familiarity cannot be compared. These estimates could have offered interesting findings as recollection - from a context-processing perspective - would be expected to be oppositely effected by congruency, as incongruent trials would allow a means of contextual discrimination based on their rarity, thus, producing another method of dissociating these theories.

As an added area of interest, a level-of-processing task was included in the procedure to examine the effect of semantic elaboration on PDP estimates, which was not guaranteed with patients in the high association condition. Consistent with previous studies (Ragland et al., 2003), we found that patients could benefit as much as healthy participants by using an organizational strategy if presented with one. Toth, Reingold and Jacoby (1994) examined LOP effects on process estimates and despite claims that familiarity underlies lower, perceptual-based processing, they found no effect of shallow processing on familiarity. This result was replicated, with increases only observed in recollection with deeper processing. Familiarity does not increase with extensive encoding of features assumed to be automatic, which is in line with Rajaram's (1996) theory of fluency based familiarity by not making the distinction between conceptual and perceptual encoding, proposing instead that familiarity is driven by the *fluency* with which a task can be performed (i.e., without conscious deliberation). While physical properties can be automatically processed as experienced in everyday life, the intention of processing them, which is incidental to the task, might violate the automaticity criteria for processing to engage familiarity, thereby producing effects for all depths only in recollection.

Discussing PDP estimates in terms of absolute increases and decreases makes assumptions about the relationship between estimates and memory. It might be inaccurate to use these values to draw inferences about how they contribute to improvements to EM performance, particularly when they act in opposition to each other. Their measure of memory ability may depend more on the *relative* influence of the process that was used at encoding, rather than its absolute value. Therefore, high influences of either recollection or familiarity could impair EM if they were not the mode in which the memory was originally processed. Analyzing memory impairments in schizophrenia should note this inferential limitation, as it is not know how these processes might interact in an impaired system. In practical terms, its is therefore important not to just compare raw differences in estimates with normal functioning, but to express them as percentages of total process influence. It was found that patients' responding in low association conditions was not only their worst performance, but was also the only condition in which their process ratio significantly differed from normal participants. This analysis was performed more demonstrably than for any investigative purposes, as since we have no conditions in which recollection would be expected to encourage inaccurate memory recall, it was

inevitable that the reduced proportion of estimate influence in very low performance conditions would be recollection among patients.

Limitations of the Present Study and the PDP

Throughout testing, many limitations of the present experimental design came to light, which made the robust findings all the more surprising. A major concern previous to testing was the validity of the word association manipulation. The norms used were taken from large sample sizes and we were not guaranteed that our small sample would follow a similar trend of perceived word association. Future studies would benefit from preliminary testing of associative baserate for individual participants, which would allow more experimental control over this effect. Another limitation which had the potential to confound results was the within subject counterbalancing of LOP depth. Since every participant experienced both levels of depths for every test item, it could be argued that once an item was deeply encoded, the participant would be able to benefit from deep processing in every subsequent trial. However, this effect was not found here as word recall was still much poorer at shallow depth. Another methodological shortcoming in this condition was highlight by the lack of an expected dramatic effect of deep processing on recollection in patients. A possible reason might be owing to their inability to use the context association of time to recall when the word-pair was present. For instance, if an individual is impaired in trial discrimination, then perhaps the stronger memory trace resulting from deeper processing might be recalled instead of the target trial. In future, studies should attempt to design procedures around the expected subtle deficits of clinical populations such as this.

The theories of episodic memory on which this study was based have et to answer many questions on the impact of strategic recall and automatically driven responses. Here it was assumed that increased associational strength gives support to accurate memory recall. Based on our findings, this corresponded with Rajaram's (1996) discrimination/fluency theory of recollection and familiarity. However, if discrimination is the caveat for which recollection is ensured, then perhaps there are ways that oppose contextual association to promote this. For example, if we replaced a low association condition in the present study with words that were as far removed from the contextual frame of the cue word as possible (i.e., judge-monkey), it might enhance the strength of the memory on the basis of a property such as its 'mismatchedness' or conflicting expectation. An effect like this could be based on

processes of error-detection used to highlight events that contradict previous learning history (Holroyd & Coles, 2002), and would be make an interesting avenue for future research.

A well documented limitation of interpreting research in schizophrenia, and was suspected to be an influence in this study, is the common finding of decreased motivation among diagnosed individuals (Barch, 2004). Measuring cognitive processes accurately is made very difficult if the participant does not make a personal effort to perform at their true ability. Due to time constraints, it was not feasibly to control for this effect in this study. Some research attempts to circumvent this limitation be using more covert measures of processing. However, as explicit recollection forms the hypotheses for much memory research, this is not always possible. The source of this confound may itself be a downstream effect of the specific context-processing deficit of binding reward and context together (Robbins & Everitt, 1996); so they patient might agree to participate in testing without any emotional valence or enthusiasm, but respond in the same manner as they do not perceive any direct benefits or harmful consequences of participation.

The PDP developed by Jacoby (1991) has become a very useful tool in research memory and has helped make interesting discovers about the influences of automatic and controlled processing in the dual-process memory system. However, since its development there has been little ground made in our understanding of the nature of their influence and their dual function in everyday life. Many studies have used the PDP to validate preexisting direct and indirect measures of memory, as well as to observe influences such as cognitive aging and confidence judgments. These studies are highly influential to shaping current models of memory, but they refine existing theories without attempting to detect unique, real life phenomena of memory. Studies that have embraced this approach have increased our understanding of topics as varied as racial bias (Payne, Lambert and Jacoby, 2002) to Freudian-slips and subliminal perception (Jacoby & Kelley, 2005). More ecologically valid studies might offer a fresh perspective on interesting ways in which these processes contribute to decisions and behaviour, which would not be predicted from lab conceived memory research.

Future Directions for Cognitive Research in Schizophrenia

We have discussed the importance of neuropsychological research in our understanding of schizophrenia by relating neural dysfunction and abnormal behavior.

However, in recent years it has played a crucial role in understanding the cause and pathogenesis of the condition. The view of this research, as it currently stands, is that schizophrenia is polygenic, with the manifest illness resulting from the combined action of multiple genes (Barch, 2005). Finding specific 'schizophrenergic' genes is a huge challenge for behavioral-genetic research, owing largely to the heterogeneity of observable phenotypes (Egan, 2001). This is likely due to the multiple pathways interactive from genetic polymorphisms to diagnosed disorder, mediated by vague environmental risk factors (Tsuang et al., 2001). For this reason, it may be advantageous to seek out phenotypes that are closer to their genetic aetiology. Cognitive impairments have been useful in this respect, as they help break clinical presentation down into specific deficits that are behaviourally identifiable and are less genetically variable (Caspi and Moffitt, 2006). Genetic research of cognitive impairments has had huge impact on current psychiatric perceptions of schizophrenia. Common genetic determinants of schizophrenia, mood disorder and autism have become the basis for an argument that these disorders share the same genetic aetiology, specified only by the number of polymorphisms and consequential degree of exhibited cognitive impairment (Craddock, Donovan & Owen, 2009). The potential of neuropsychological approaches applied to schizophrenia is demonstrated here, and is encouraging to neuropsychological research of other pervasive psychiatric disorders.

Beyond understanding and scientific discovery, it is important for research of psychiatric conditions to have clinical implications. Until recently, efforts to use neuropsychological research for clinical implementation such as cognitive enhancement therapy had mixed degrees of efficacy (Gould et al., 2000). Fortunately, these efforts have been used in other areas with much more success. A mental health strategy in the United States has been developed to allow clinicians to benefit from breakthroughs in neuroscientific research in schizophrenia. The Cognitive Neuroscience Treatment Research to Improve Cognition in Schizophrenia (known as CNTRICS) is a group comprised of leading researchers with the objective of identifying and testing areas of cognition of interest to clinicians in the treatment of schizophrenia and also the in development of paradigms for assessing cognitive ability and screening for markers of the disease. The strategy was formed in an effort to provide incentives to adopt a 'molecule to medicine' approach for researches in standardizing and translating neuropsychological tests. The problem they identified was that in vetting for psychometric validation, neuropschological instruments were

required to be rigorously tested to show a 'robust and reproducible measure of the dimension of cognitive function for which it was targeted' (Cohen & Insel, 2008, p.2). As Cohen and Insel (2008) note, this usually resulted in only well established but out-dated measures being chosen for selection. With this new strategy, the opportunity to improve outcomes in schizophrenia from cutting-edge neuropsychological research is vastly improved and will allow this approach the power to make contributions at all levels of the disease.

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Appendix A

Table 7. Stimuli used in experiment and associative norms from free recall (from Jacoby, 1993).

Cue	Fragment	High Association	Baserate	Low Association	Baserate
apple	-or-	core	.66	worm	.00
basin	--sh	wash	.73	dish	.10
bread	cru--	crumb	.79	crust	.18
car	m-t--	motor	.62	metal	.02
cigar	bu--	butt	.71	burn	.13
chair	-e-t	seat	.61	rest	.04
heart	l-v-	love	.88	live	.11
judge	ju--	jury	.73	just	.04
lake	po--	pond	.71	pool	.16
lamb	wo--	wool	.74	wolf	.19
loud	-oi-e	noise	.86	voice	.05
wine	g-a--	glass	.61	grape	.26
swim	fi--	fish	.71	fins	.11
thief	s-ea-	steal	.64	sneak	.03

Appendix B

Figure 8. Health Service Executive ethical clearance letter.

Feidhmeannacht na Seirbhíse Sláinte
Health Service Executive

HSE West,
Mid-Western Regional Hospital,
Dooradoyle,
Limerick, Ireland.

Tel: 00353 (0) 61 301111
Fax: 00353 (0) 61 301165
Website: www.hse.ie

12th June, 2009.

Mr. Garrett O'Connell
Psychology,
The University of Edinburgh,
7 George Square,
EDINBURGH EH8 9JZ.

Re/ Protocol Title
Associative Context Retrieval in Individuals with Schizophrenia: Contributions of Strategic and Automatic Processes.

Dear Mr. O'Connell,

I am in receipt of your study as above submitted for review by our Research Ethics committee. I have reviewed the contents of same.

I wish to advise that I have given your study Chairperson Ethic's approval.

You should note that your study cannot commence until you also receive approval from the Risk Management Department. You are obliged to inform us as soon as your study is completed or if it terminates early for any reason. This approval will be issued to you shortly.

I wish you every success in your study.

Yours sincerely,

Marie Hickey Dwyer,
Consultant Ophthalmic Surgeon,
Chairperson, Ethics Research Committee.