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A classification of ellipsis based on a corpus of information-seeking dialogues.

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Abstract

The standard classification of ellipsis has determined the way it is handled in natural language understanding (NLU) systems. This work provides a novel classification of ellipsis based on the analysis of ellipsis usage rather than forms in a corpus of information seeking dialogues. The aim is to demonstrate that pragmatic analysis is necessary for the interpretation of ellipsis. The context, in terms of the dialogue participants' belief states, determines interpretation and in turn the interpretation of the ellipsis changes the context for the interpretation of subsequent utterances. The dialogues produced in a NLU system using this classification are presented.

INTRODUCTION

Elliptical utterances are an integral part of information seeking dialogue. Carbonell and Hayes (1983) found that users partaking in dialogue with a database interface persisted in the use of ellipsis even when requested not to. The opportunity was taken, wherever possible, to omit part of an utterance which could be inferred from the context to allow for a more natural communication. As such, it is of no surprise that various techniques have been proposed for a computational approach towards the resolution of this phenomena within natural language understanding (NLU) systems. These techniques generally rely on a classification of ellipsis according to its *form* for interpretation. The aim of this paper is to show that a pragmatic approach is needed which resolves ellipsis interpretation according to its intended *usage* in the dialogue.

A corpus of dialogues was analysed to provide the basis upon which the pragmatic classification of ellipsis could be developed. This demonstrates that the given context, in terms of the dialogue participants' belief states, gives rise to interpretation and that recognition of the intended usage of the ellipsis can be seen as a function which changes the context for the interpretation of subsequent utterances. To facilitate this in the proposed classification, the usage of the ellipsis is characterised directly in terms of its context changing effect (in line with Beun (1990) and Bunt(1989)).

The elliptical utterances in dialogue [1][1] illustrate the core of the problem addressed in this paper.

[1] S1> Is there a Maths Degree course at UMIST?
H1> There is a Maths Degree course at UMIST
S2> the entrance-requirement?
H2> The Maths course at UMIST requires 2 A-levels and 3 O-levels
S3> a Computer course?
H3> There is a Computer Degree course at UMIST. It requires 2 A-levels and 3 O-levels.

The speaker's intention in uttering S2 is clearly a request to find out more detail about the course found as a result of S1. The contextual information is then used to provide a cooperative response to S3 in which the existence of the requested course and its entrance requirement is given, H3. The intention of the speaker is, however, difficult to recognise but will provide the updated context for the interpretation of subsequent utterances. That is, if the ellipsis is understood to have been used to switch attention from one course to another, the hearer may expect the speaker to gather similar details about another

[1] The dialogues are labelled to show the turns of the speaker (S) and the hearer (H) which correspond to the information seeker and the informant respectively.

course or to continue to find out more detail about the Computer course. Alternatively, the speaker may have uttered the ellipsis with the intention to consider taking either the Maths or the Computer course. In which case subsequent utterances may be made to gather more details about both the courses. Now, if the speaker continues in the dialogue to request "*the duration?*" should the hearer refer this to both of the courses or only to the most recently mentioned course? The proposed classification provides for this interpretation of intention. The incorporation of this requirement represents a departure from the previous approaches to ellipsis resolution.

THE TRADITIONAL CLASSIFICATION OF ELLIPSIS

Contextual ellipses, which rely on the recovery of omitted information from previous utterances, may be sub-classified according to structural relationships of the elliptical form and its antecedent (Quirk et al, (1972)). These may be of three types as described below and exemplified in dialogue [2]

Replacement, where the ellipsis shares and replaces a syntactic category and semantic type with its antecedent (**S2**).

Elaboration, where the ellipsis refers semantically to its antecedent (**S3**).

Repetition, where the ellipsis is structurally and semantically identical to the antecedent (**S4**).

[2] S1> Is there a Maths course at Manchester University?

H1> Yes

S2> A Physics course?

H2> Yes

S3> the duration?

H3> 4 years

S4> 4 years?

A NLU system which bases its approach to the resolution of contextual ellipsis on this classification will, it follows, rely on the syntactic and semantic information sources. The various approaches that have been developed differ primarily in respect to the grammar formalism adopted (Bobrow et al (1977), Hendrix et al (1978), Waltz (1978), Kwasny and Sondheimer (1979), Hayes and Mouradian (1980), Wieschedel and Sondheimer (1982), Carbonell (1983, 1985), Frederking (1988), Trogstad et al (1988)).

Pragmatic analysis to determine the communicative function of an utterance, why it was said in relation to the context, has been used to deal with **telegraphic** ellipses. These can only be understood from the context, especially when used in the opening sequence of a dialogue. The pragmatics-based system from Allen and Perrault (1980) includes a plan recognition strategy for such instances of ellipses (e.g., "*the train to Windsor?*"). Carberry (1989) also uses a plan-based framework to deal with elaboration elliptical utterances within an information seeking dialogue. She recognises that elaboration ellipsis may be used

with the intention to carry out a **depth search** in which the information seeker investigates all aspects of a particular course before moving on to look at aspects of another course. The interpretation of ellipsis is obtained using the entire context of a speaker's plan which is built up during the dialogue. This provides an effective treatment of elaboration ellipsis. The interpretation of S3, dialogue [1], illustrates that the use of such a contextual model also provides an effective treatment for replacement ellipsis. However, Carberry's system in providing for depth searching does not handle replacement ellipsis since it is often used with the intention to analyse aspects of several courses, in a **breadth** search. This essentially was the question posed earlier, was a depth or breadth search intended in dialogue [1]?

A NLU system must deal with both elaboration and replacement ellipses and therefore some procedure is needed which is, perhaps, less restrictive than a plan based analysis. A corpus of information seeking dialogues was analysed to establish the relative importance of each ellipsis type. This also establishes the properties of dialogue which may be used in the sought interpretation of ellipsis.

ANALYSIS OF THE DIALOGUES

The corpus of dialogues was collected using a Wizard of Oz

experiment[2]. This had been developed to collect dialogues for the PLUS project in the Centre for Computational Linguistics at UMIST (Jokinen, (1991)). The system allows a user to query a database unaware that the responses are provided by another person at a remote terminal. The subjects were mostly 2nd year students from the Department of Language and Linguistics. Additional subjects were collected from commercial institutions, a bank and the BBC. They all had some computer experience, but their knowledge about NLU systems, if at all, was limited. When asked they all admitted to being fooled into thinking that a computer system was communicating with them.

In total, 48 dialogues were collected using the Wizard. The subjects were given a scenario to encourage information seeking dialogue about car-hire firms, restaurants, insurance companies, educational courses or a conference, and were told to communicate with the system as naturally as possible, as if talking to another person. A dialogue conducted over a telephone was included for comparison of spoken and typewritten dialogue (Beun (1990)).

The quantitative analysis of the ellipsis type is given in **Table 1.** The number of each ellipsis type is shown as the percentage of the total number of utterances in each dialogue set. The actual number of examples found is given in brackets

[2] For a detailed discussion on these, see Diaper (1989)

below. The Total column is the percentage of each type out of the total 162 ellipses found.

Dialogue > *Ellipsis v*	Tele-phone	Confe rance	Insur -ance	Car-hire	Rest-rnt	Cour-ses	Total
Repetition	3.5 (3)			0.3 (1)	0.3 (1)		3 (5)
Response		0.7 (1)	12.3 (17)	9.1 (29)	9.2 (31)	7 (9)	53.7 (87)
Elaboration	1.2 (1)	2.8 (4)	4.4 (6)	3.4 (11)	2.7 (9)	7.7 (10)	25.3 (41)
Replacement		0.7 (1)	2.2 (3)	0.9 (3)	1.8 (6)	3.9 (5)	11.1 (18)
Replacement (Negative)				0.3 (1)	1.8 (6)	1.6 (2)	5.5 (9)
Telegraphic		0.7 (1)		0.3 (1)			1.2 (2)

Table 1.

General Observations on Ellipsis

Some observations can be made regarding the types of dialogues and ellipsis use. In the conference dialogues there was relatively little use of ellipsis. This may be due to the informant's use of language which was verbose and polite and this in turn affected the type of language used by the information seeker. An example of this effect is shown in corpus dialogues A and B (**Appendix 1**). Similarly, the higher percentage of ellipses in the courses dialogues may be attributed to the fact that the wizard actively encouraged its usage. Once the wizard began to use elliptical utterances the user tended to follow the trend. Overall, telegraphic and repetition ellipsis did not occur frequently. It may be that repetition ellipsis, is associated with speech rather than typewritten dialogue, for example, when used to ensure that something was heard correctly. Whereas telegraphic ellipsis may be associated with different types of dialogue, such as those connected to a specific plan of action, e.g., catching a train. Ellipsis was mostly used as a response, however the interpretation of this is trivial since the expectation of a response is high following a question. Elaboration ellipsis has been analysed in depth by Carberry (1989), therefore our interest lies specifically with the use of replacement ellipsis, although the proposed scheme is applicable to all types.

The dialogues were analysed not only for the occurences of ellipses, but also to reveal the requirements for a computational approach to resolution. The corpus dialogues given in **Appendix 2** are illustrative of the requirements specified for interpretation. Dialogues [C] and [D] confirm the need for contextual information to determine what is referred to in an ellipsis and to provide a cooperative response. Dialogues [E] and [F] illustrate the need to recognise intention. Where this cannot be inferred from the context, [E], a breadth search should be assumed since less effort is required to correct to a depth search, [F]. In contrast, replacement ellipsis is clearly used in a depth search when it follows a negative response, [G].

REPRESENTATION USED IN THE CLASSIFICATION

These observations led to the development of a classification scheme. Since it was intended that the scheme would be used in a NLU system, the representation of context is based on that of the processed utterances in the proposed system, (Johnson, (1992)). This enables the parsed utterances to be mapped onto the scheme. Each utterance is parsed in the system using a categorial grammar enhanced with compositional semantics to give a logical representation which is suited to further manipulation. To meet this requirement the representation is built up, as follows, to give the context giving rise to interpretation and updated for subsequent interpretation in logical form.

It is assumed that in making an elliptical utterance, a speaker presupposes that there is a proposition to which the ellipsis refers and the belief state about this will determine the interpretation. For example, the value denoted in the elliptical utterance, "*Maths*?", presupposes that there is some proposition about some object which has an attribute of value Maths. Thus, the semantic content of an elliptical utterance is not of a propositional nature until the ellipsis has been resolved. For example, the utterance, "Maths?" gives rise to the expression:

exists(o) exists(A) [inst(o,_) & A(o,maths)].

This can be thought of as an existential presupposition concerning an object which "Maths" is predicated. In the representation scheme, all attributions are shown as binary predicates, hence an attributive relationship A is also presupposed. In using a higher order logical representation, the propositional content of the resolved ellipsis subsumes its presuppositions. The contextual interpretation of the ellipsis can now be represented by the following:

The utterance. This is simply represented as u.

The antecedent belief state as seen by the speaker. This is the belief state held by the speaker about the proposition to which the ellipsis refers. The belief operators which take a proposition as the argument are B_x, I_x and K_x, where B, I and K stand for believe, intends and know respectively. The subscript x denotes the information seeker (the speaker, s) or the

informant (the hearer, h).

The presupposition of the elliptical utterance. This is represented by the predicate name or proper name which represents the semantics of the lexeme or phrase used in the utterance. The example used above for the utterance Maths? can be expressed in general terms:

exists(o) exists(A) [inst(o,_) & A(o,v)].

Where v is the value denoted in the utterance which can be attributed to some object.

The denotation of the utterance. This is represented as the value denoted in the utterance. For example, the denotation of the utterance, Maths? is the v in the presupposition since `Maths' is a value of an attribute of an object.

The effect that the interpretation of the utterance has on the belief state of the hearer can also be shown. This is represented as follows:

The communicative act. This is the hearer's interpretation of the speech act intended, i.e., question (QUE) or statement (STATE). The consequent, or the updated belief state of the hearer. Since the communicative function of an utterance can be characterised directly in terms of its context changing effect, the belief state of the hearer is updated as a consequent of the utterance. This is represented in the scheme using the belief operators which take the proposition resulting from the interpretation of the ellipsis as the argument.

THE PRAGMATIC CLASSIFICATION OF REPLACEMENT ELLIPSIS

Three uses of replacement ellipsis are represented in the scheme. Following this, the use of the scheme and its implications on ellipsis interpretation in a system is shown.

Replacement-Correction Ellipsis

Replacement ellipsis may be used for the purpose of correction, a depth search, whereby an adaptation of the non-linguistic plan is indicated, as in [3]. The use of a clue phrase, the pragmatic verb-phrase "I meant", indicates the speaker's intention.

[3] S1> Are there any Italian restaurants in Fallowfield?
H1> Don Giovanni 228-2482
S2> I meant French.

The conditions and consequents of the interpretation of replacement-correction ellipsis in the scheme are shown in **Table 2.** This stipulates that the speaker has some belief state about the antecedent, proposition p^1, $B_s B_h p^1$ where p^1 = exists(o) exists(A) [inst(o,restaurant) & A(o,italian)]. This may be used to resolve the ellipsis to produce a new proposition, p, where p = exists(o) exists(A) [inst(o,restaurant) & A(o,french)].

The consequent is that the speaker wants to know the instance of

an object for which the value denoted in the utterance is true, (QUE). In addition, since the elliptical utterance introduces a new proposition into the dialogue the hearer must also update a belief state about the speaker's plans and goals, assuming that intention corresponds to the intended result of the speaker's plan. Prior to the elliptical utterance in [3], it is mutually believed that the S is pursuing a plan deduced from the interpretation of the previous utterance, p^1, to gather information about Italian restaurants. This can be represented as plan(p^1). Following the elliptical utterance, it is inferred that there has been a change of plan, $B_h I_s K_s p$ & B_s correct_plan(p^1).

Utterance	u
Content	v=D(u)
Antecedent Belief State	$B_s B_h p^1$
Presupposition	E(o) E(A) [inst(o,_) & A(o,v)]
Communicative Act	QUE
Consequent	$B_h I_s K_s p$ & B_s correct_plan(p^1)

Table 2: The correction use of replacement ellipsis.

Of more interest is the use of replacement-correction ellipsis to alter an information seeking plan following a query which fails to result in a successful response, [4]. This

differs from the above example since the S is not necessarily intending to indicate that Italian restaurants are not of interest. Rather, the S is forced to adapt to the circumstances of a negative response.

[4] S1> Are there any Italian restaurants in Fallowfield?
H1> No
S2> what about French?

In order to distinguish this usage of replacement ellipsis from the plan correction scenario above, the conditions are seen to be different. The speaker believes the negation of the proposition p^1, B_sB_h not(p^1) where p^1 = exists(o) exists(A) [inst(o,restaurant) & A(o,italian)]. This is used to resolve the ellipsis to produce a new proposition, p, exists(o) exists(A) [inst(o,restaurant) & A(o,french)].

The consequent is that the speaker intends to know the value of p, (QUE) and wants the hearer to believe that the plan inferred from p^1 has been altered, $B_hI_sK_sp$ & B_s alter_plan(p^1). The context and consequent of this interpretation of replacement-correction ellipsis are shown in **Table 3**.

Utterance	u
Content	v=D(u)

Antecedent Belief State	$B_s B_h$ not(p^1)
Presupposition	E(o) E(A) [inst(o,_) & A(o,v)]
Communicative Act	QUE
Consequent	$B_h I_s K_s p$ & B_s alter_plan(p^1)

Table 3: The correction use of replacement ellipsis (2).

Replacement-Reformulation Ellipsis

The reformulation, (or breadth search) use of replacement ellipsis may be represented using the scheme. Having obtained the information requested about Italian restaurants, the S intends to pursue a goal of finding some alternative restaurants, [5].

[5] S1> Are there any Italian restaurants in Fallowfield?
H1> Don Giovanni 228-2482
S2> what about French?

This can only be distinguished from the correction use of ellipsis if it does not follow a negative response or a clue phrase, in this case "what about", is used to indicate reformulation of a plan. The consequent is that it is believed that the speaker intends to know the instance of an object for which the value denoted in the utterance is true, (QUE) and

that the speaker intends for it to be mutually believed that the plan denoted in the previous utterance is reformulated $B_h I_s K_s p$ & B_s reformulate_plan(p^1). The conditions and consequent for this interpretation are shown in **Table 4**.

Utterance	u
Content	v=D(u)
Antecedent Belief State	$B_s B_h p^1$
Presupposition	E(o) E(A) [inst(o,_) & A(o,v)]
Communicative Act	QUE
Consequent	$B_h I_s K_s p$ & B_s reformulate_plan(p^1)

Table 4: The reformulation use of replacement ellipsis.

The new context is one in which the S is seen to be considering simultaneous plans (about Italian and French restaurants). This is likely in information seeking dialogues in which the speaker plans to discover all the options (or in this case, restaurants) available and then begin to narrow these down by specifying certain conditions (such as, the opening times).

THE CLASSIFICATION SCHEME IN USE

The representation developed for ellipsis classification was put to use in a NLU system. Its suitability is due to its

simplicity: no additional information is necessary for the pragmatic interpretation of ellipsis.

Each utterance is parsed and translated to its logical form. In dialogue [6], User1>, the predicates of the logical form are mapped to predicates in the world knowledge domain giving,

```
p = exists(x)&inst(x,course)&level(x,degree)&subj(x,maths)&location(x,umist)
```

Information provided as a result of subsequent utterances referring to this, User2>, is simply added to update p,

```
p = exists(x)&inst(x,course)&level(x,degree)&subj(x,maths)&location(x,umist)&
entry(x,[exam(a_level,2,_),exam(0_level,3,_)]
```
[3]

When the replacement ellipsis, User3>, is encountered it also is parsed,

```
exists(x)&inst(x,_)&subj(x,physics)
```

and its interpretation is based on the available proposition, p, for reference giving,

```
p1 = exists(x)&inst(x,course)&level(x,degree)&subj(x,physics)&location(x,umist)&
entry(x,[exam(_,_,_),exam(_,_,_)]
```

The effect is that default replacement-reformulation is assumed so that both p and p1 remain available for reference. This is shown to be the case in the response to User4> where the translation of the utterance,

```
exists(x)&inst(x,_)&duration(x,y)
```

is used to update both propositions.

[3] This is read as exam(type,number,subjects). The logical representation of sets and their cardinality in not a topic here.

In effect, the scheme makes use of a stacking mechanism to state which propositions are available for reference. In particular, it controls what remains on the stack following an ellipsis.

[6] User1> Is there a Degree course in Maths at UMIST?

System1> course c9 has subject Maths, award Degree, at UMIST

User2> the entrance-requirement?

System2> course c9 requires 2 A-levels, 3 O-levels

User3> What about in Physics?

System3> course c12 has subject Physics, award Degree, at UMIST requires 2 A-levels, 3 O-levels

User4> the duration?

System4> course c9 has duration 3 years
course c12 has duration 3 years

User5> Is the Physics course full-time?

In dialogue [7], the representation following System2>,

`not(exists(x)&inst(x,course)&subj(x,physics)&location(x,umist))`

can be used to resolve the ellipsis, User3>, but as a result the updated context is one in which only the Maths course is available for reference.

[7] User1> Is there a Degree course in Physics at UMIST?

System1> course c12 has subject Physics, award Degree, at UMIST

User2> in Maths?

System2> No information in the database

User3> at Manchester Polytechnic?

System3> course c7 has subject Maths, award Degree, provider Manchester Polytechnic

CONCLUSIONS

The aim of this paper was to develop a theory of ellipsis as a pragmatic phenomena. The classification was developed using a corpus of information dialogues and illustrates that ellipsis may be used for different purposes in a dialogue. The analysis established that to handle ellipses in information seeking dialogues, a context model is needed which represents the belief states of the participants to recognise the communicative function of an elliptical utterance. We cannot say that context affects or even determines interpretation and then ignore the effect this interpretation has on the context. Thus the aim of a NLU system must be to arrive at the intended interpretation of the ellipsis so that a cooperative response can be provided and the effect of the utterance is accounted for by updating the context accordingly. The corpus dialogues and those handled in the system illustrate that the proposed approach meets these aims and in doing so demonstrate that effective use can be made of limited knowledge in a NLU system. The stacking mechanism used, controlled by the scheme, suggests that ellipsis should be treated as a form of anaphora in a system.

This work also has wider implications for the development of NLU systems. It illustrates the desirability of modelling the system's requirements on what is actually observed in dialogues between man and machine. This way, realistic and useful dialogue handling capabilities may be developed. If people conduct, on the surface, simple dialogues then the machine should be able to respond as cooperatively as possible with the available, and often limited, information.

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APPENDIX 1

These dialogue extracts from the corpus illustrate the effect that the use of language from one dialogue participant can have on the other. The first, [A], is part of a dialogue between two people via different terminals where one was acting as the informant (I) and the other as the information seeker(S). The I is polite and helpful and likewise S uses verbose utterances to express the requirement. In the second dialogue, [B], the information seeker thought that a prototype computerised information service was being used. Both I and S were abrupt and direct.

[A] I1> Trygg-Hansa is in Vasag, 45 and has telephone number, 81900

S2> Is there any information about the costs for the different insurances?

I2> No, unfortunately we don't have such information.

S3> maybe I ought to have the address and the telephone to the other large insurance companies too.

[B] I1> The following companies in town hires private cars:
- Budget Rent a car, Odinsg. 8, tel. 200770

S2> the cheapest alternative?

I2> Information not available.

S3> Is there more information?

(Source: PLUS project – Gothenburg University)

Appendix 2

The requirement of **contextual information** to determine what is referred to in an ellipsis is confirmed in dialogue [C]. This informs the hearer of utterance S3 that the cost of the hotel has been established. The utterance, therefore, must refer to the new information about the cost of the hotel meals and not to the cost of the hotel itself. The latter interpretation would be arrived at if based on the substitution of some structural correlate alone. Dialogue [D] illustrates how a context model could have been used to provide a cooperative response to the elliptical utterance based on the interpretation, *"What Indian restaurants are in Withington and what are the opening hours?"*.

[C] S1> What is the total cost of the conference,
including the flight and the hotel?

H1> £85 registration, £213 Hotel Du Roi and
£185 flight altogether that's £473

S2> Will I have to pay extra for meals?

H2> No all the meals are included in the registration fee.

S3> What about the hotel?

H3> The hotel will provide breakfast.

[D] S1> What Indian restaurants are in Fallowfield?

H1> Curry cottage 224 0376 and

Night of Raj 431 5726

S2> What are the opening hours?

H2> 6pm to 2am

S3> in Withington?

H3> Shezan 224-4392

S4> Have you more information?

H4> The opening hours are 5pm to 12 midnight

The recognition of intention is found to be necessary to provide a new context to base the interpretation of subsequent utterances, [Dialogues E and F]. In [E], the usage of ellipsis (S2) is interpreted as a depth search, as only the Computer course is referred to in S3, however the speaker's utterance in S4 suggests that a breadth search is intended so that both courses are to remain in focus and referred to. In this case, the intention cannot be recognised from the context and it is suggested that a breadth search should be assumed by the use of replacement ellipsis as in [F]. If needed, less effort is required to correct a breadth search to a depth search (e.g., This could be done in [F] with the utterance "When does the Computation course start?"). In contrast, the context given in dialogues, such as [G], allow the intention of the ellipsis to be recognised. Here it is used to continue the dialogue to a satisfactory conclusion following a negative response and therefore only the Computer course is referred to in S3.

[E] S1> What are the entrance requirement to study Maths at Manchester University?

H1> GCE `A' Levels

You must at least have a Maths `A' Level

S2> the qualifications needed for Computer Science

H2> BSc(Hons) in Computer Science at Manchester University. You must at least have a Maths `A' Level

S3> what about a non Degree course like HND

H3> There is an HND(BTec) course in Computer-Studies at Manchester Polytechnic. It requires 2 GCE `A' Levels and Maths and English at `O' level

S4> non Degree courses in Maths?

H4> There are no HND courses in Maths listed

[F] S1> I want information on Maths Degrees at UMIST.

H1> BSc(Hons) in Mathematics at UMIST.

S2> the names of Computer courses.

H2> BSc(Hons) in Computation at UMIST

S3> the qualifications needed?

H3> The Computation course requires 3 GCE `A' Levels.

The Maths course requires GCE `A' Levels and

You must at least have a Maths `A' Level

S4> Can you tell me what grades are needed?

H4> BCC for the Computation course

BBC for the Maths course.

[G] S1> Can you tell me about courses in Maths at Manchester University?

H1> BSc(Hons) in Mathematics at Manchester University

BSc(Hons) in Mathematics at UMIST.

S2> Computer courses?

H2> There are no details on Computer courses at Manchester University

S3> any at Manchester Polytechnic?

H3> BSc(CNAA) in Computer-Studies at Manchester Polytechnic

BSc(CNAA) in I.T at Manchester Polytechnic

HND(BTec) in Computer Studies at Manchester Polytechnic