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INVITED ADDRESS

COGNITION AND REAL MUSIC: THE PSYCHOLOGY OF MUSIC COMES OF AGE[1]

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It is argued that developments in the cognitive psychology of music have recently made it possible to claim that a genuine paradigmatic enterprise is now in existence. The features of this paradigm include an agreed set of central problems together with agreed methodological and theoretical perspectives. A particular sign of maturity is the increasing attention which psychologists are paying to the processes involved in the perception, creation, and performance of real music under conditions which have a high degree of naturalism. It is suggested that the theoretical contribution of Lerdahl and Jackendoff (1983) epitomises the concerns of this paradigm, and the move towards naturalism is illustrated through studies of normal and exceptional memory for real musical material.

The past ten years have seen such qualitative and quantitative changes in the psychology of music that it is tempting to make a provocative claim. The claim is that until about ten or so years ago there was no scientific discipline which deserved the title "psychology of music". Books had been written with this name. Research into music had been carried out using the techniques of experimental psychology. But something essential was lacking. I would loosely adopt Kuhn's (1962) thinking and say that only in the last ten years has the basis for normal paradigmatic science in the psychology of music emerged.

I believe that there are five important characteristics of a healthy paradigm: an agreed set of central problems; agreed methods for working on these problems; agreed theoretical frameworks in which to discuss them; techniques and theories which are specific to the paradigm; research which is appropriate to the whole range of phenomena in the domain being studied.

Although parts of this recipe have been present in different research endeavours, the full set has only recently emerged at one time and within a research community who intercommunicate their ideas and results.

[1] This paper is an edited version of an invited address delivered at a symposium on the psychology of music organised by the Belgian Society for Psychology, Brussels, December 1985.

How and why such a discipline should emerge at this particular point in time is a question for sociologists and historians to pursue. Nonetheless, it is abundantly clear that public *foci* such as conferences and journals have played a crucial part in sustaining the paradigm. Journals such as *Music Perception* and regular conferences (e.g., Clynes, 1982) have been, and continue to be vitally important to the health of the discipline.

Let us take each of the five characteristics of a paradigm in turn, and elaborate on them in the context of the psychology of music.

THE AGREED PROBLEM

There seems to be a growing consensus that a central problem for the psychology of music is to explain *the structure and content of musical experience*. This is not to deny the importance of studying the processing of musical material, but this approach puts the emphasis onto the endpoint of processing — what the processing is supposed to achieve. This involves examining two major questions: a. What is the nature of musical knowledge or representation?; b. How does music have aesthetic and emotional effects?

Both questions are of central importance, but the majority of research has focused on the first of these two questions. I would judge that this definition of the problem excludes much that has been loosely called psychology of music. It, for instance, excludes many studies in music education where the prime aim is to test a teaching method, and where the prime research measure is some measurement of the technical improvement of the learner. I am not denying that music learners have musical experiences, nor that the nature of these experiences contributes to the nature of the learning. It does seem, however, that much research in this area either ignores, or makes simplistic assumptions about, the nature of the experience.

There are, however, research studies in other apparently more cognitively oriented programmes which I would also want to claim are somewhat peripheral to our major concerns. These are the studies which derive their data from musical situations, but which do not attempt to explain their musical significance. Such findings are certainly important and worthy of discovery, but they do need considerable interpretation before they contribute to the psychology of music. Research by Vos and Rasch (1982) that I much admire illustrates this well.

They have shown that perceived onset of a musical note is related to its rise time. The slower the rise, the later the onset appears to be. This has practical implications. For instance, instruments with slower rise times will have to play earlier than others if they are to sound simultaneous. But these findings generalise to any generated sounds whatsoever, musical or not. What might be the specifically musical significance of synchrony and asynchrony? McAdams (1982) has shown that perceived onset asynchrony encourages us to hear two sounds as separate, whilst synchrony encourages fusion. This now begins to relate to musical issues. Perhaps asynchrony is a way of emphasising polyphony, whilst synchrony encourages perception of homophony. We may then begin to ask questions about what other features of a musical stimulus contribute to the experience of polyphony or homophony. And now we begin to move into the realm of core psychology of music. The questions which we would want to answer in this are: What effects on the musical experience do different types of synchrony patterns have? Why do musical performers choose particularly large or small asynchronies at particular points? Can we identify structural features of music which we would predict to be associated with certain asynchrony patterns? And so on.

One of the seminal publications in our young discipline was Longuet-Higgins' (1976) paper in *Nature*. Longuet-Higgins wrote a computer simulation which took a sequence of pitches and durations as input, and produced a sensibly notated version as output. His thesis was that a central part of experiencing any music *as* music is the assignation of sounds to positions in tonal and metrical space. This involves determining the key of the melody and its principal stresses. The heuristics in the program are embodiments of strong psychological hypotheses about an experienced listener's processing mechanisms. This research is central to the psychology of music not only because it directly addresses the central problems, but also because the analyses it provides actually accord well with "the intuitions of experienced listeners", and thus have a strong claim to be an empirically verified account of music experience. The insights of Longuet-Higgins have found echoes at the core of several more recent theoretical enterprises (e.g., Balzano, 1980; Lerdahl & Jackendoff, 1983).

Agreed methods

Some of these methods have been arround for a long time. Maybe no one is specific to psychology of music, but recent years have seen researchers exercising a greater freedom to use many different methods to complement one another. In particular, many researchers are eschewing the strait-jacket of traditional methodologies such as the same-different recognition experiment, and are exploring a whole range of methods:

1. Direct recording of performance parameters. This has seen a recent renaissance following the explosion of availability of computer technology for handling and analysing such data (Clarke, 1985; Gabrielsson, 1974; Michon, 1974; Rasch, 1979; Shaffer, 1981, 1984).

2. Computer synthesis of sound patterns to test perceptual hypotheses, sometimes coupled with prior analysis of music with method 1 (Gabrielsson, 1985; Sloboda, 1985a; Sundberg, Askenfelt & Fryden, 1983).

3. Measurement of memory performance. Recognition measures, usually of computer synthesised stimuli, are common (Cuddy, Cohen & Miller, 1979; Deutsch, 1982; Dowling, 1978; Edworthy, 1985; Tan, Aiello & Bever, 1981). Less common are studies of musical recall (Deutsch, 1980; Sloboda & Parker, 1985).

4. Studies of verbal behaviour connected with music, such as judgements about qualities of music, and protocols. These have been most particularly connected with aesthetic aspects (Crozier, 1974; Smith & Cuddy, 1986), but also such processes as composition (Reitman, 1965; Sloboda, 1985b).

5. Studies of physiological correlates of musical experience. These include evoked potentials, heart rate and other autonomic measures, also studies of hemispheric differences (Davidson & Schwartz, 1977; Harrer & Harrer, 1977; Hirshkowitz, Earle & Paley, 1978, McKee et al., 1973).

6. Simulations of aspects of music perception (Longuet-Higgins, 1976), performance (Sundberg & Fryden, 1985), or generation (Sundberg & Lindblom, 1976; Ulrich, 1971).

A principal concern of all these methods is increasingly to measure or control the *microstructure* of the music or the behaviour. Investigators are concerned to discover how the specific actions and events contribute to the global phenomenon. It is no longer adequate, for instance, to simply record the number of errors in some task. We wish to know exactly what errors were made and where.

Agreed theoretical frameworks

A convergence is detectible in the central assumptions made by researchers working in this discipline. Some of these are: Music is constructed according to grammar(s) (Sundberg & Lindblom, 1976); representation is often hierarchic (Deutsch & Feroe, 1981; Martin, 1972); tonality, metre, and rhythm are psychologically real organising principles (possibly instantiations of musical universals) (Lerdahl & Jackendoff, 1983); different processes (composition, performance, perception) access the same core representations (Sloboda, 1985b).

This by no means shows that theoretical agreement has been reached, but it does prescribe the kind of things that are theoretically interesting to researchers. In particular, it is arguable that those who hold the above assumptions will particularly want theory to account for: errors in performance, their nature and position; distribution of expressive parameters in performance; differential memorability of musical passages; differential perceived salience of musical events; judgements of well-formedness by listeners; cultural differences in music perception; processes of enculturation and learning, and skill-level differences; structural determinants of musical meaning.

Specificy of the activity

There has been a tendency among researchers to become interested in music because it is a good example of something else: e.g., a complex motor skill; a language-like phenomenon; a complex auditory phenomenon; a set-theoretic entity.

Of course, music is all these things, and it is important to bring in ideas from other areas to elucidate music; but it is possible that many of us, including myself, have been too eager to see music through the spectacles of our own extra-musical preoccupations, and underplay its uniqueness.

It is most precisely at the point where our studies characterise music as wholly *unlike* anything else that we may be most secure at establishing a real psychology of music. We may locate this uniqueness of music at the confluence of three aspects: 1. Music creates a non-referential world; 2. It does so through the psychological dimensions of tonality and metre; 3. Despite the lack of reference, music has deep emotional significance.

Rhythm and metre are, of course, concepts which have parallels in other domains, such as speech (Martin, 1972). Tonality, however, seems something quite unique to music. The study of scales, harmony, melody, and key seems to be what gives our subject its specificity and its heart. We have begun to unravel the rich and complex structure which makes the tonal system such a fruitful medium for building interesting forms (e.g., Longuet-Higgins, 1972; Balzano, 1980). We have done less to relate tonality to the emotions, but it is becoming much more respectable to pose this as a question for research effort (e.g., Minsky, 1982).

Appropriate research

1. Music psychology demonstrates its maturity by starting to address the *range* of activities properly described as musical. Although the majority of research relates to perception, increasing research effort is devoted to examining such activities as performance (Clarke, 1985), memory (Sloboda & Parker, 1985), composition (Lerdahl, in press) and improvisation (Davidson, 1985; Pressing, in press).

2. Music psychologists are becoming more concerned to use real music in their investigations instead of impoverished music-like stimuli. It is being realised that certain aspects of music will not be understood unless materials of some complexity are used. This does not entail giving up stimulus control; however, more researchers use relatively long sequences (two or more phrases) (Sloboda & Gregory, 1981; Tan et al., 1981), ensure that both rhythmic and tonal structures are present (DeLiege, 1985), and try to use "composed" material rather than "constructed" material where feasible (Pollard-Gott, 1983). This is part of the move towards greater "ecological validity".

3. Music psychology increasingly employs subjects in behaviours that are close analogues of common musical activities, such as memorising for recall (Sloboda & Parker, 1985), sight-reading (Sloboda, 1984), extended listening (Pollard-Gott, 1983), improvising (Sagi, in press).

4. Music psychology has come to address issues which are not simply of interest to psychologists, but to practitioners of the various arts and skills of music (performers, music theorists, etc.). We find increasing numbers of professional musicians undertaking psychological research, often in collaboration with psychologists (Rosner & Meyer, 1982; Sternberg, Knoll & Zukofsky, 1982). Collaboration of various kinds has been particularly encouraged by such bodies as the *Institut de Recherche et de Coordination Acoustique/Musique* (IRCAM) in Paris.

The coming of age

The title of this paper commits me, if I am serious about my analogy, to identify a precise historical moment which signified the coming of age of our discipline. I have no doubt at all about what this moment was. It was the publication in 1983 of Lerdahl and Jackendoff's *Generative Theory of Tonal Music*. This is for several reasons:

1. It must be one of the most comprehensively reviewed books in music/psychology (Cady, 1983; Child, 1984; Clarke, 1986; Longuet-Higgins, 1983; Peel & Slawson, 1984; Rosner, 1984). The avid interest with which it was awaited and then devoured by a very wide constituency signals the community of concern around the problems it addresses. It was recognized that the authors had articulated a core problem for music theory and psychology, and had attempted an ambitious answer.
2. It has the problem of the structure of musical knowledge as its main theme.
3. It is explicit and detailed. It offers rules for understanding the perceived importance of each note in an extended piece of music.
4. It is "universal". It can account for anything from a small fragment of music right up to a symphonic movement. It also attempts to be universal in another sense, in proposing that culturally specific rules are special cases of culture free rules which apply to all music.
5. It is ambitious. It tries to offer a complete theory which will cover most real music.
6. It is specific. Although many of the structures are borrowed from other domains, notably generative linguistics, the way they are applied to music is unique for a. the notion of several independent but interactive structural analyses of the same passage, b. the distinction between well-formedness rules and preference rules, c. the proposal of special rules to deal with such music-specific events as cadences.
7. It is empirically oriented. The authors claim that specific predictions of the theory may be tested.
8. It is written with the contribution of a highly trained working musician who is prepared to use his own musical intuitions and insights as the basis of theory.

These features do not necessarily imply that Lerdahl and Jackendoff have produced a theory without flaws. The longer we live with it the more apparent its shortcomings are. This is not the point. The mere existence of the theory has significantly accelerated the amount of thinking and research around the problems it addresses (Deliege, 1985; Narmour, 1983; Todd, 1985). In "coming out" the authors have undoubtedly laid their heads on many chopping blocks, but had they not done so, fewer people would have been motivated to sharpen up the particular hatchets. Lerdahl and Jackendoff are to be congratulated for making themselves so explicit that criticism of them is relatively easy and fruitful. By seeing what they do not do, we should be able to make rapid progress in developing better theories. Any discipline which cannot produce a steady stream of theories of the clarity, complexity and elegance of Lerdahl and Jackendoff, is certainly not to be judged mature. We may have come of age, but we still have a long way to go.

It is particularly heartening to see that Lerdahl and Jackendoff have stimulated diverse type of endeavour. Music theorists have held it up against other theoretical and analytical perspectives (see Clarke, 1986). Scientists have started to conduct empirical studies aimed at testing certain of its predictions. For instance, work carried out in Shaffer's laboratory (Todd, 1985) shows that the pattern of timing deformations in expressive playing can be predicted quite closely from patterns of prominence derived from a Lerdahl-Jackendoff analysis.

Although some studies have arisen specifically with reference to Lerdahl and Jackendoff's theory, many more have been carried out within the general climate that has been responsible for the intense interest in their work. I would like to illustrate this point with reference to two studies that I have been recently involved with (Sloboda & Parker, 1985; Sloboda, Hermelin & O'Connor, 1985). They both concern a "real" musical task, that of memorising composed music for subsequent recall. One study looks at "normal" processes in relatively unselected subjects. The other study looks at a single case of "exceptional" memory. In each study a principal concern is with the type of representation which must be postulated to account for memory distortions.

RECALL OF FOLK TUNES

Although memory has been a major concern of the psychology of music, almost all the serious research has been conducted using a recognition method. Subjects are presented with two short music-like sequences and they are required to detect some difference.

David Parker and myself decided to explore a more direct approach, of playing a real tune to subjects and asking them to attempt to recall, by singing, what they could remember (see Sloboda & Parker, 1985 for further details). The study was devised as a preliminary step on the road to investigating how musicians go about memorising long pieces of music, a topic we know almost nothing from the viewpoint of empirical science.

Secondly, it seemed to us that a memory recall would provide the most detailed, rich, and explicit clues to the nature of the structures and representations that people use when dealing with tonal music. In particular, an analysis of the type of error made should tell us a great deal about the structures being picked up.

Thirdly, extensive literature search failed to discover any similar analysis of a corpus of recalls.

The data were collected as follows. Short but unfamiliar folk melodies were played on the piano and tape recorded. Subjects were tested individually by listening to each melody and then trying to sing it back to "la" or any other convenient syllable. Each melody was repeated six times in succession, and so six consecutive recalls were obtained.

Figure 1 shows the melody to which we have devoted our major attention. It is the first 12 bars of a Russian folk song called "Sailor". It contains 30 notes. None of our subjects had heard it before.

Fig. 1 — Stimulus melody in Sloboda and Parker (1985) study.

Figure 2 shows transcriptions of the six recalls of a single subject on repeated presentation of the tune. This set of recalls displays features typical of the corpus as a whole. Firstly, the recalls are remarkably coherent and definite. This makes them easy to transcribe and analyse. We had fears of vague mumbled hummings which would be impossible to transcribe. Our fears were groundless. Second, not a single recall in our whole corpus is note perfect. Third, everyone who has heard these recalls agrees that the subjects display real memory for the music.

We have subjected the data to a number of analyses which have corroborated these intuitions. First we showed that subjects do not retain a large proportion of the actual melodic and rhythmic sequences

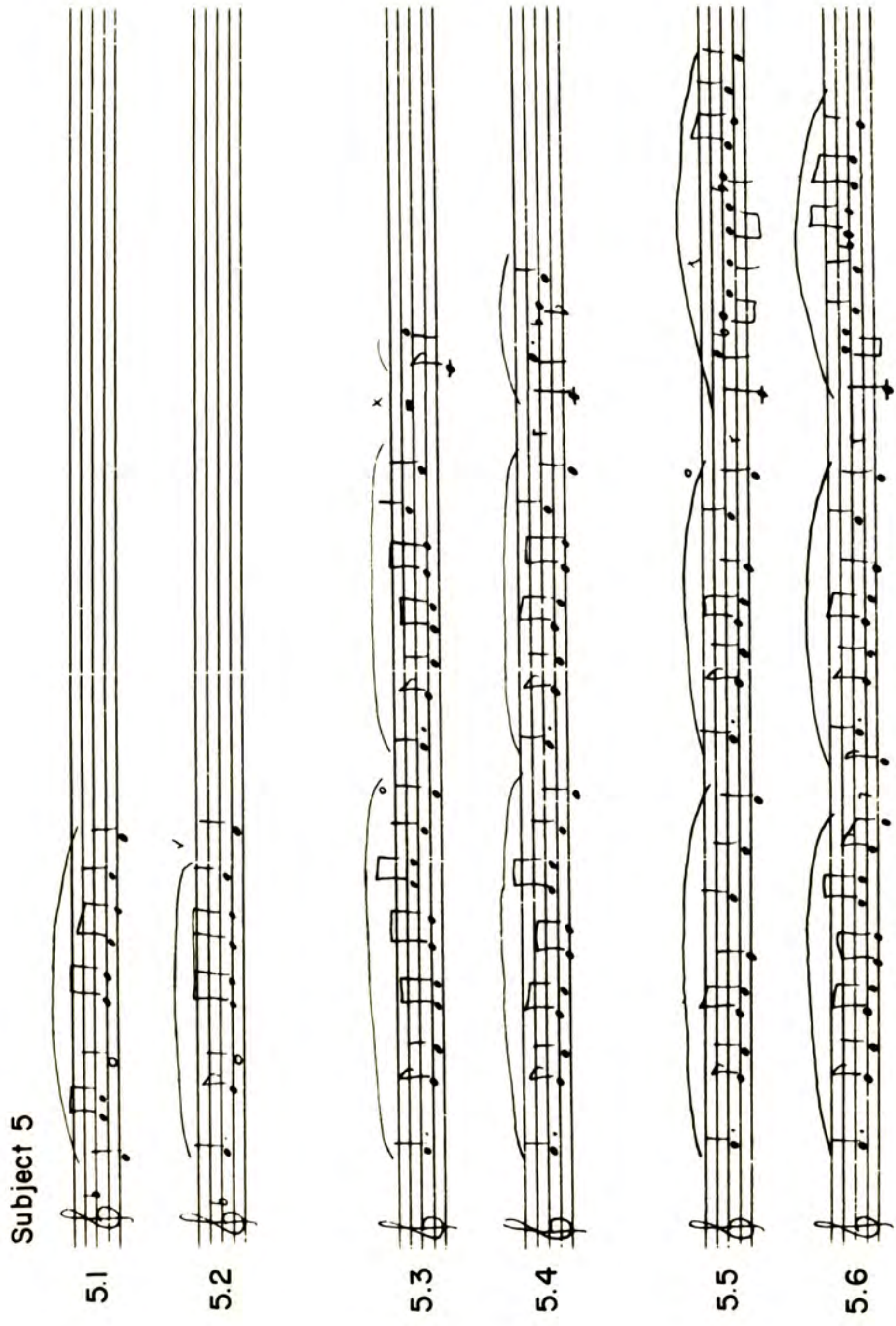

Fig. 2 — Transcriptions of six consecutive recalls of a typical subject in Sloboda and Parker's (1985) study.

present in the original. Even when we give considerable latitude in the positioning of material average scores are still low. Expressed as a percentage of total notes recalled, only 43% of the notes matched the melody given, and only 46% matched the rhythm given. One interpretation to place upon this would be that for about half the time subjects were improvising at random to sustain the melody. We have evidence, however, that their productions were constrained by high-level features of the original melody.

The first of these features is the metrical structure. We found that we could satisfactorily parse 88% of the recalls as in consistent 4-beat metre, like the original, by applying the kind of parsing rules formalised by Lerdahl & Jackendoff, and others. In other words, subjects were extracting the metre of the original as a frame for their recalls.

The second of these features is harmony. In this case we found quite wide subject differences. Half of our subjects were music students, the other half were just interested in music. In the case of the music students 81% of the material was harmonically appropriate. That is to say, whilst the material was melodically and rhythmically new, it used notes from the chords implied in the original. We scored the recalls by looking at the notes subjects chose to begin each half-bar, giving a score of 1 if the note came from the chord prescribed by the original at that point. Figure 3 gives an example of memory which is harmonically and metrically perfect but contains almost none of the actual notes of the original.

Fig. 3 — Example of recall of phrase 1 in Sloboda and Parker's (1985) study.

A third higher-order feature of these recalls concerns phrases. It should be clear that the original melody falls into three phrases of two bars each. The second phrase rather closely imitates the first, but the third phrase introduces new material. Subjects showed awareness of this structure in two ways, through breath positions, and through imitative relations between phrases:

1. *Breaths*. In each subject's recall we defined the end of phrase 1 as the last note in bar 2 whose duration was a crotchet or longer. The end of phrase 2 was similarly defined as the last long note in bar 4. We then compared the number of times subjects breathed at a phrase end to the number of times they breathed elsewhere. Almost every phrase end was

associated with a breath, and almost no other point was. Subjects made the phrase structure explicit through their breathing,

2. *Imitative structure*. We asked whether subjects preserved the imitative relationships between phrases 1 and 2, making the third phrase different. To do this we took each recall, and compared phrase 1, beat by beat, with phrase 2, awarding a score of 1 if the pitches were identical, and a score of 1 if the rhythms were identical. We found that phrases 1 and 2 had a 71% match, whereas phrases 1 and 3 had only a 41% match. So, as in the original, subjects preserved the closer relation of phrases 1 and 2.

How do we summarise our findings? They show that a trivially simple ecological technique coupled with appropriate data analyses yields good insights into structural aspects of musical memory. They suggest that memory of a tonal melody involves building up a model of the underlying structure in which not all of the surface details are necessarily retained. Recall involves a reconstruction process which fills in structural slots according to general constraints. The type of structure noticed depends to a certain extent on experience. In our sample only the musically trained show a majority retention of harmonic structure. All the subjects were able to access the metrical and phrase structure.

An exceptional musical memory

The second study I wish to report is of a much more dramatic and sensational kind. We saw in the previous experiment that ordinary people, even those with musical training, are not very good at retaining exact details of even a short melody. Yet musical folklore abounds with stories of people gifted with quite exceptionally accurate musical memories. The most famous story probably concerns Mozart's exploits with Allegri's *Miserere* (Anderson, 1966). However trustworthy we believe the observers of this feat of memory to be, the actual record of the attempt does not survive. It would be of considerable interest to examine a contemporary musician with memory powers equal to that claimed for Mozart.

A rigorous examination of such a memory would not only be of intrinsic fascination, it would also have theoretical significance. We could ask whether a prodigous musical memory is the result of some abnormal mode of representing music (such as a vivid "eidetic" store) or whether it comes about through the same kind of structural assimilation as more mundane memory.

If the former, then we would expect it hardly to matter whether the material to be remebered was easily assimilable to well learned structures. If the latter, however, we would expect music containing familiar structures to be remembered better than music lacking some of these structures. We would also expect any errors that did occur to be predominantly structure preserving.

In 1984, an opportunity presented itself to examine a young man of allegedly remarkable memory powers for piano music (see Sloboda, Hermelin & O'Connor, 1985 for further details). He had been discovered during a large scale study of *Idiots savants*. These are people of low intelligence, often mentally handicapped, who appear to have an isolated pocket of intellectual excellence. A small number of such people excel in music. Sometimes their excellence is only relative to their mental age; and the skill would not be unusual in a normal person with some musical training. This particular man, who we shall call NP, was particularly interesting because his alleged memory skill was far in excess of any normal accomplishment. The claim was that he could memorise an extended movement in two or three hearings.

NP was 22 years old at time of testing. He lives in a home for the autistic, and displays the typical range of autistic symptoms, including language deficiency, social withdrawal, gaze aversion, and obsessive behaviour patterns. His major obsession is music. He spends as much of every day as possible playing the piano or listening to music.

Prior to the experimental sessions, a number of piano pieces were prerecorded on tape. In the event, we were able to expose NP to two of them, neither of which, to our knowledge, he had learned before: 1. a Lyric Piece by the 19th Century Norwegian Composer Edward Grieg ("Melodie" Opus 47 no 3); 2. a short atonal piece by the 20th Century Hungarian Composer Bela Bartok ("Whole Tone Scale" from Mikrokosmos Book 5).

Neither piece was technically virtuosic, and well within the technical capacity of the subject. In the trials, NP simply listened to the recordings. At no stage did he see anyone visually demonstrating the appropriate motor movements on the piano, nor did he have the chance to examine a score. NP heard each entire piece through, then heard it in shorter sections, as judged appropriate from the signals he gave, and his moment to moment capacity. After each presentation of the piece (or section) he was asked to try and play what we had heard. The whole session was recorded on tape, and all recall attempts were transcribed for analysis.

We found that NP learned the Grieg piece to almost note-perfect criterion in about 12 minutes, during which time he heard no more than four repetitions of any section of the piece. The piece is 66 bars long and contains 310 notes (discounting adjacent repetitions of the same chord). Figure 4 shows a summary learning history. The upper white bar of each pair shows what NP heard on a given trial. The lower black bar shows what was recalled. Although recall was never 100% perfect, the deviations from score were very minor; an occasional omission or addition of a subsidiary note which hardly changed the character, and never the structure.

Table 1 shows some summary quantitative data. The top figure is the number of notes whose recall was attempted over all trials. The second figure is the number of wrong notes (sum of notes omitted which should have been played and notes played which should not have been). The third figure is the number of times that there was a stumble, pause, or backtrack. The fourth figure represents the wrong notes and stumbles as a percentage of notes attempted, to give a gross error rate.

Tab. 1 — Summary quantitative data of the exceptional musical memory study

	NP		AS	
	Grieg	Bartok	Grieg	Bartok
Notes attempted	798	277	354	153
Notes wrong	54	137	265	12
Stumbles, pauses	11	37	19	10
total % error	8	63	80	14

Table 1 includes data from a number of comparisons that help us to understand better the nature of NP's achievement with the Grieg. The second column shows data from NP's attempt to recall the Bartok piece. Although shorter than the Grieg, and with just as simple a rhythmic and formal structure, the reproduction attempts were hesitant, error-prone and unconfident. For instance, in four attempts to recall the first 51 notes of the piece, NP never played more than 36 correctly, and each time with frequent stumbles. Although many fewer notes were attempted overall, the error rate was a massive 63%. It appears that NP cannot function at a high level outside the framework supplied by conventional tonal harmony.

A second comparison summarised in Table 1 comes from the attempts of a professional pianist AS to memorise the same two pieces. AS was an approximate age and experience control for NP. Figure 5 shows the learning history for the Grieg piece in the same format as Figure 4 for NP. The hatched bars are recalls containing large numbers of errors.

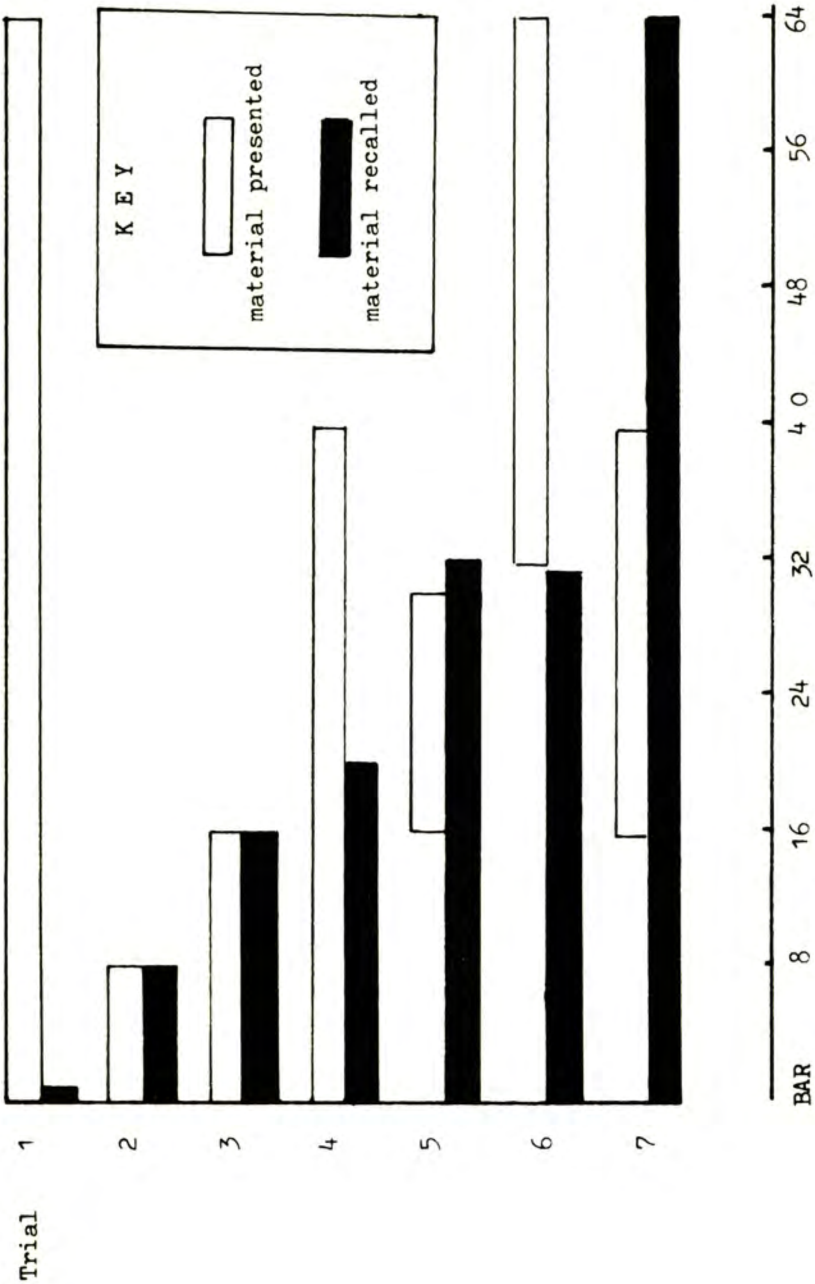

Fig. 4 — Learning history for subject NP on Grieg Op 47 no 3 (from Sloboda, Hermelin & O'Connor, 1985).

This shows that good recall was obtained for the first 8 bars alone. When further material was attempted, even the original level of performance on the first eight bars was lost. It was clear that AS was simply overwhelmed by the amount of material in the Grieg. Although some of the right hand melody was reproduced reasonably well, the accompanying chords bore no resemblance to the original for significant portions of the recalls.

The Bartok, in contrast, showed negligeable error. This was partly due to the brevity of the section attempted (first 8 bars only), but it was clear that the atonality did not disrupt AS to anything like the extent that it did for NP. Like many contemporary musicians, AS had considerable experience of this kind of music.

A third comparison was obtained by looking at the results of some simple tests of NP's verbal memory. This was found to be consistent with his general level of intellectual functioning. He had a forward digit span of 5 (as compared to an average of 7) and a backwards span of 4 (as compared to an average of 6). He was able to recall simple 7-word sentences haltingly but correctly, but could only recall 4 out of 7 words when word order was jumbled. There was no evidence of any exceptional memory capacity outside the realms of tonal music.

It is quite clear from these data that NP is not the possessor of some primitive but high-capacity "echoic" or "mimicking" memory, but has a narrow but intensely highly-developed window of "normal" memory which operates, as in most known cases of expertise, by representing material in terms of familiar higher-order structures. This ability, like other exceptional skills, has been developed through many thousands of hours of practise over many years, in conjunction with an intense degree of absorption with the material concerned, and an unusually high degree of motivation to succeed at this particular task (cf. Chase & Ericsson, 1981).

In sum, these two studies illustrate how naturalistic musical situations may be exploited to provide insights into the nature of musical representation. They accord well with the theoretical perspectives formalised by Lerdahl and Jackendoff, in that they suggest overlapping structured hierarchic representations of music (rhythmic, metrical, tonal, etc.), where higher levels have greater "durability" than lower levels.

Conclusions

The type and range of endeavours summarised in this paper convinces

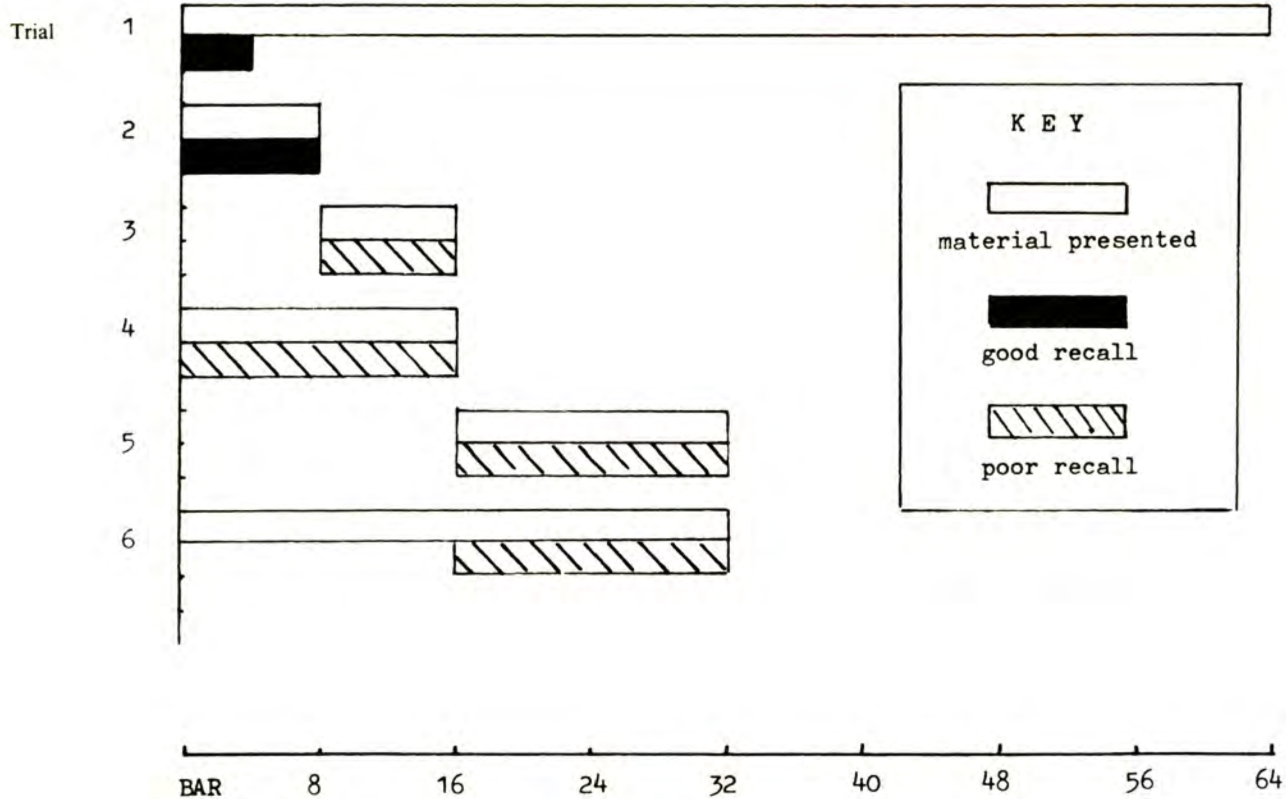

Fig. 5 — Learning history for subject AS on Grieg Op 47 no 3 (from Sloboda, Hermelin & O'Connor, 1985).

me that our discipline of Psychology of Music has indeed come of age, and that we can happily take risks. We no longer need to convince a sceptical psychological world that we have rigour, scientific respectability and relevance. Rather, we should boldly extend the frontiers of our subject by tackling some of the outstanding difficult issues head-on.

Lerdahl and Jackendoff have set new standards for comprehensiveness and boldness in theory. Let us hope that they stimulate not only criticism but other, even bolder, theories. Many empirical workers have broken new ground in subject matter. The upsurge in performance studies is a most impressive development of the last five years or so. It is particularly heartening to see people attempting to systematically observe some real phenomenon just because it is there to be examined, and has inherent importance. A favourite study of mine is one by Gruson (in press), who had the courage to tackle the question of what goes on when people practice the piano. Do people of different skill level do different things? Her painstaking analysis of session tapes showed that indeed there are important and reliable differences across skill levels. The study raises as many questions as it solves, but it is a fine example of the pioneering work which will move our discipline forwards.

I would like to conclude by mentioning some areas which I believe are ripe for an intensification of psychological investigation. Firstly, it would be good to see many more psychological studies on the processes of composition and improvisation. Secondly, we would benefit from more studies on the processes of musical communication in ensembles, examining, for instance, the role of the conductor. Thirdly, we need more studies which give information on the mental processes that take place when listening to extended music. There are a whole range of unanswered questions about the type of memory representation which is built up, particularly in early listening, about the role of imagery and the emotions. Fourthly, we need systematic investigation of large scale memorisation skills in professional performers and others.

Early attempts will be unsophisticated and much criticised, but the territories must be claimed. So, I invite those who are committed to bringing about the true maturity of our subject to tackle precisely those questions that their caution tells them are much too difficult. That is the way forward, I am sure.

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