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The Mozart effect: Tracking the evolution of a scientific legend

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Theories of the diffusion of ideas in social psychology converge on the assumption that shared beliefs (e.g., social representations, rumours and legends) propagate because they address the needs or concerns of social groups. But little empirical research exists demonstrating this link. We report three media studies of the diffusion of a scientific legend as a particular kind of shared belief. We studied the Mozart effect (ME), the idea that listening to classical music enhances intelligence. Study 1 showed that the ME elicited more persistent media attention than other science reports and this attention increased when the ME was manifested in events outside of science. Study 2 suggested that diffusion of the ME may have responded to varying levels of collective anxiety. Study 3 demonstrated how the content of the ME evolved during diffusion. The results provide evidence for the functionality of diffusion of ideas and initial elements for a model of the emergence and evolution of scientific legends.

Social psychology and the diffusion of ideas

The problem of how ideas spread within and between social groups is an important element of understanding culture, social stability and social change, but it has remained an underexplored topic in social psychology. This is partly due to mainstream social psychology's emphasis on experimental research. Experimental social psychology has contributed much to the understanding of behavioural and attitude change *in individuals*, but the processes involved in the diffusion of ideas often occur on a time scale that precludes experimental study.

Not that there is no interest in how ideas spread. Indeed, some approaches advocate the study of ideas and their spread as a central focus of social psychology (e.g., Bartlett, 1932; Fraser & Gaskell, 1990; Moscovici, 1984; Sperber, 1990). Moreover, they converge on key assumptions. In particular, many of them assume that the spread of ideas is *functional*, in that they spread because they fulfil a motivational need of an individual or a group. For example, social representations are postulated to help laypersons symbolically cope with unfamiliar and potentially menacing scientific and technological innovations (Wagner, Kronberger, & Seifert, 2002), or rumours are assumed to spread

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in response to uncertainty and anxiety (Allport & Postman, 1947). But critics (Jost & Ignatow, 2001) have noted that these assumptions have remained largely untested.

Here, we provide evidence for functional claims in social representations by investigating a particular class of representation, a *scientific legend*. Scientific legends are widespread beliefs (Fraser & Gaskell, 1990) derived from science that diffuse and stabilize in lay culture (Moscovici, 1992). They are a particularly interesting class of social representation because their origins can be located specifically enough to study the entire life-cycle of their evolution and diffusion. We studied the Mozart effect (ME), the idea that exposure to classical music (especially the music of Mozart) improves intelligence. Originally based on controversial scientific results, it has enjoyed widespread popularity because it promises a potential solution to a perplexing social and parental concern: how to ensure the intellectual development and growth of children. Our findings suggest that ideas may indeed diffuse and evolve to meet the functional needs of social groups.

Theories of the diffusion of ideas

In this section, we review three major theoretical approaches to the diffusion of ideas. We then highlight converging theoretical predictions about the functional nature of social ideas and define 'scientific legends'.

Social representations: Popularization of science

Social representations theory (see Deaux & Philogène, 2001; Farr & Moscovici, 1984; Flick, 1998a) emphasizes the social processes by which expert knowledge, especially science and technology, is transformed into common sense. Scientific research and technological innovations are diffused in the media or introduced into everyday routines. These ideas and technologies are often confusing to the lay public. Moreover, they may challenge existing social practices, beliefs or ideologies, thus threatening social identity and creating resistance (Bauer, 1995; Biotechnology and the European Public Concerted Action group, 1997).

Social representations arise through the efforts of groups to 'cope' symbolically with these unfamiliar ideas and practices (Wagner *et al*., 2002). They result from the assimilation of scientific knowledge into pre-existing schemes of thought. For example, psychoanalysis is assimilated to the religious rite of confession (Moscovici, 1961), madness is anchored in folk theories of organic illness (Jodelet, 1991), AIDS is conceptualized as a divine punishment for homosexuality (Markovà & Wilkie, 1987), genes are thought to be injected into genetically modified food and to be 'contagious' to humans (Wagner *et al*., 2002), and sex-role stereotypes from everyday interaction are used to interpret the mating behaviour of animals (Green Staerklé & Clémence, 2002) or the interaction between sperm and ovum during conception (Bangerter, 2000; Wagner, Elejabarrieta, & Lahnsteiner, 1995).

In summary, social representations may allow lay communities to cope with the unfamiliar discourse of science and technology by anchoring it in more familiar concepts from everyday life. But the idea that social representations function to reduce uncertainty and threat to social identity has been criticized for lack of evidence. Jost and Ignatow (2001) argue that the descriptive approach taken in most such work, focusing on the *content* of social representations, does not constitute support for claims about their *functions*, writing that 'at present, the most interesting functional claims are untested' (p. 197).

Rumours and legends

The literature on rumours and legends is spread over several disciplines, but converges on core ideas. In general, legends have a somewhat more complex plot structure than rumours, but researchers in both the area of rumours and legends often analyse the same kinds of stories (Allport & Postman, 1947; Brunvand, 1981; Rosnow & Fine, 1976), so for our purposes we emphasize commonalities among the two literatures.

In psychology, Allport and Postman's (1947) classic study of rumour identifies importance of information and ambiguity as two important factors determining the spread of rumour. Rumours function (p. vii) to 'alleviate intellectual uncertainty and personal anxiety'. They do so by relieving, justifying and explaining underlying emotional tension (p. 36). Rumours are presented as truth, despite the fact that the evidence that backs them up has grown vague through retelling. But Allport and Postman's experimental studies were limited to describing transformations of content in retellings (see also Bartlett, 1932), and their functional speculations about rumours and anxiety were not tested.

Subsequently, scholars in psychology, sociology and folklore studies have echoed the belief that rumours and urban legends arise and propagate in response to pre-existing concerns or anxieties (Brunvand, 1981; Dégh, 1994, 2001; Festinger, 1957; Fine, 1980; Glassner, 1999; Koenig, 1985; Rosnow & Fine, 1976; Shibutani, 1966; Showalter, 1997). But this hypothesis has rarely been subjected to empirical test—typical studies postulate some concern or anxiety that may drive a particular rumour without attempting to measure the amount of concern in a population, or the relationship between concern and how the rumour spreads. Indeed, other than a few studies that have shown that people who are more dispositionally anxious are more likely to spread rumours (see, e.g., Anthony, 1973), we know of no research that has measured anxiety levels in a population and then examined whether rumours are more successful in circumstances where anxiety is high.

Evolutionary approaches

Evolutionary approaches borrow analogies from the natural sciences, arguing that the diffusion of ideas is analogous to the spread of a virus or the replication of a gene. The theory of memetics (Blackmore, 1999; Dawkins, 1976; Lynch, 1996) proposes that contagious ideas, or 'memes', proliferate by inducing their hosts (brains) to propagate them in a variety of ways. An example is the chain letter (Goodenough & Dawkins, 1994) that promises good luck to recipients if they send copies of the letter to others, and bad luck if they do not. Another evolutionary approach (Sperber, 1990) proposes using an epidemiological strategy to understand how beliefs propagate and stabilize as part of culture. However, both the memetics approach and the epidemiological approach have fostered little empirical research.

Convergence between theories

Previous work in several different theoretical traditions has assumed that the spread of ideas fulfils some psychological or social function. Ideas seem to propagate best when there is a good fit between them and their social environment. Work on social representations assumes that people need to cope with the unfamiliar ideas and practices introduced by science; work on rumours and urban legends has typically assumed that people pass along rumours or legends to allay widespread anxieties or apprehensions; and evolutionary approaches assume that memes adapt to fit the psychological environment of their hosts. However, we have been unable to locate any studies that

have systematically measured some property of the social or psychological environment and then related it to the diffusion of an idea. Thus, despite strong convergence in theoretical predictions, the approaches above are in the uncomfortable position of being unable to provide much systematic evidence for a key assumption (Jost & Ignatow, 2001).

Scientific legends

We define a 'scientific legend' as a widespread belief (Fraser & Gaskell, 1990) that propagates in society, originally arising from scientific study, but that has been transformed to deviate in essential ways from the understanding of scientists. Moscovici (1992) suggests that one of the main functions of such beliefs is to circumvent an 'interdict of knowing' (p. 4) that separates science from lay culture.[1] Although scientific knowledge and research is undoubtedly affected by cultural beliefs (Flick, 1998b), we focused in the present study on how knowledge moves from science to lay culture.

Modern culture seems to be replete with beliefs originally derived from scientific studies (Moscovici, 1992). Examples include various factoids (e.g., the idea that two arbitrarily chosen people in the world are separated from each other by only six degrees of separation, or that Eskimos have hundreds of different words for snow, or that we only use 10% of our brain). Other beliefs are richer in content, such as the idea that the left brain hemisphere is analytical and logical, whereas the right hemisphere is intuitive and holistic.

We propose that scientific legends are in many ways analogous to other shared beliefs such as rumours and legends. One common aspect seems to be their functional nature. Another is the fact that, in a generally sceptical society, these beliefs have developed informational credentials (Fragale & Heath, 2004) that apparently guarantee their veridicality or accuracy. These may include appeals to authority, pseudo-references to proximal sources (e.g., 'a friend of a friend') or specific details that increase plausibility. In the case of scientific legends, there is often a formulaic reference to 'scientists' or 'scientific studies'. As an example, consider the following clause (in italics) appended to a description of the ME: '*According to studies conducted in the West*, babies who hear Cosi Fan Tutte or the Mass In C Minor during gestation are likely to come out of the womb smarter than their peers …' (*South China Morning Post*, August 25, 2000). Such devices exploit the epistemic authority of science in modern society to lend credibility to the legend.

Scientific legends are particularly interesting because they offer two points of comparison that allow us to understand more precisely how ideas evolve as they diffuse. They offer a normative comparison because they allow us to contrast understandings of expert scientists and the lay public, and they offer a specific temporal comparison because we can often locate the original study upon which a scientific legend is based. Thus, although the ME is surely related to ancient, deep-seated cultural ideas about the beneficial powers of music, it is a more circumscribed phenomenon whose central attributes (e.g., the label 'Mozart effect', the often-cited references to a specific study)

[1] *Moscovici and other authors (Bruer, 1999; Kagan, 1998) have used the term 'myth' to label similar concepts; in this usage, the term often has the connotation of an untrue belief. In folklore studies, the discipline that most often studies this kind of widespread belief, myths and legends both describe narratives that people tell as true, but myths are sacred stories set in a remote past peopled by non-human characters and embodying foundational beliefs, whereas legends are set in the world of today and involve humans (Dundes, 1984, p. 9). Thus we find 'legend' more appropriate than 'myth', although both terms suggest narrative form. We note that many examples of widespread beliefs about science, including the ME, contain both narrative ('In a scientific study, researchers found that playing Mozart to children enhanced their intelligence') and factual ('playing Mozart makes kids smarter') components.*

can be traced to a certain point in time. In typical research on rumours and urban legends (e.g., Brunvand, 1981) it is difficult to isolate the 'original' version of a rumour or legend. By studying diffusion of a scientific legend, we can find its original version (the original scientific study) and can watch as it diffuses and evolves in the environment. Scientific legends thus provide a unique opportunity to view the entire life-course of a social representation. In what follows, we describe the evolution of the ME in science and lay culture before presenting our studies.

The Mozart effect in science and lay culture

Science

In 1993, a scientific report entitled 'Music and spatial task performance' was published in *Nature*. College students who listened to a Mozart sonata for 10 minutes increased their performance on a subsequent spatial intelligence test by 8–9 IQ points in comparison to control conditions where they either listened to relaxation instructions or sat in silence for identical periods of time (Rauscher, Shaw, & Ky, 1993). This finding became known as the 'Mozart effect'. These results inspired further research, with mixed results (e.g., Steele, Bass, & Crook, 1999). In 1999, a meta-analysis of 16 such studies came to the conclusion that the overall effect size was negligible (Chabris, 1999).

The first author of the original report also led studies showing that music training in the form of piano keyboard lessons led to long-term enhancement of spatial reasoning in preschoolers (Rauscher, Shaw, Levine, Ky, & Wright, 1994; Rauscher *et al.*, 1997), and even that rats exposed to Mozart's music demonstrated better maze navigation performance (Rauscher, Robinson, & Jens, 1998). These results do not bear directly on the ME in its narrow sense, but they have been cited as support for the more general thesis that 'musical experience may improve skills in … spatial domains' (Rauscher *et al.*, 1998, p. 427). As shown by the meta-analysis, the ME has not fared well as a scientific theory. We now turn to its impact in lay culture, which has been nothing short of phenomenal.

Lay culture: The Mozart effect as a scientific legend

The ME is omnipresent in US culture, where the media and various interest groups quickly saw in it a new, easy technique for enhancing intelligence. It has been cited in public debate ranging from arts education funding to the impact of early stimulation on intellectual development (Bruer, 1999). In 1998, the state of Georgia passed a bill to distribute free classical music CDs to new mothers. In an interview, the governor of Georgia and initiator of the bill said: 'As you know, the brain has two lobes. The studies show that music engages both hemispheres of the brain—its creativity and emotion engage the right lobe, while rhythm and pitch engage the left. So people who receive musical exposure at a young age develop a bundle of nerves that connects those two halves'. (*Baltimore Sun*, July 6, 1998)

Several other US states adopted this trend. The state of Florida passed a bill requiring state-funded day-care centres to play classical music every day (State of Florida Senate Bill 660, May 21, 1998). Books (Campbell, 1997, 2000), toys and CD collections have been marketed claiming beneficial effects of classical music. And in surveys we have conducted in California and Arizona (total N = 496), over 80% of respondents report some familiarity with the ME.

The ME has diffused abroad, and appears in dozens of countries around the world. In 1996, the BBC's Megalab series tested over 8,000 students for an improvement in spatial intelligence after listening to either Mozart or rock music. In its spread, the ME

has adapted to local frames of reference: an Indian newspaper describes the ME as 'music curry for the soul' (*Times of India*, March 2, 2001). Other manifestations seem comical: playing Mozart to prison inmates (*Houston Chronicle*, May 2, 1999) or even to roses during their germination (*Korea Herald*, May 22, 1999).

All evidence suggests that the ME has become a scientific legend. It seems to be a circumscribed manifestation of a widespread, older belief that has been labelled 'infant determinism' (Kagan, 1998), the idea that a critical period early in development has irreversible consequences for the rest of a child's life. It is probably also anchored in older beliefs in the beneficial powers of music (e.g., soothing 'the savage breast').

Research questions

We present here three empirical studies. Our first study concerned the genesis and evolution of the ME. Many scientific articles receive attention in popular culture, but not all of these become scientific legends. How successful was the ME in relation to other scientific articles? And how did interest in the ME evolve over time? These questions were addressed in Study 1.

In Study 2, we sought to account for the diffusion of the ME. Why was it so successful compared to other scientific studies? Many approaches to diffusion suggest that shared concerns or anxieties in a community are an important factor influencing the spread of an idea. Guided by this assumption, we showed that widespread public concern in the US about early childhood development may have created a demand for information that helped the ME to thrive.

In Study 3, we looked at how the content of the original ME idea evolved over time. A central focus of social representations theory is that popularization of science makes unfamiliar ideas familiar by anchoring them in shared frameworks and beliefs, thereby transforming their content. The ME has been discussed in hundreds of newspaper articles since its appearance. How do these depictions differ in content from the original scientific findings, and do they converge over time on a core version?

All three studies involve media analyses of daily newspapers using a commercially available database, Dow Jones Interactive, which supports full-text searches of thousands of English-language periodicals around the world.[2] We used media analyses because many scholars have emphasized the role of the mass media in the diffusion of legends and social representations in popular culture (Dégh, 1994; Flick, 1998a). The term 'popular culture' is, of course, a gloss for a number of different groups (e.g., publishers, legislators, advertisers, educators, interest groups), but we did not analyse their relations in detail, nor did we answer questions about the patterns of influence between these groups (e.g., agenda-setting; McCombs, 1981). Because we were interested in the diffusion and reconstruction of scientific findings in popular culture, newspapers were a convenient and face valid way of tracing such ideas.

STUDY 1: Media interest in the Mozart effect

In Study 1, we tracked media interest in the ME on two levels. First, we compared the impact of the ME report to that of other scientific reports (Study 1a). Secondly, we analysed media interest in the ME over time (Study 1b). We discuss both studies together.

[2] *Soon after submission of this article, Dow Jones Interactive was replaced by the Factiva database run by the same company.*

Study 1a: Comparing the ME to other journal articles

Method

For the first part of our analysis, we compared the long-term impact of the original ME report, 'Musical and spatial task performance' (MSTP; Rauscher *et al.*, 1993), with that of other scientific reports. We searched all articles of the top 50 US newspapers by circulation for citations of reports published in *Nature* within a month on either side of MSTP. We used the key phrase 'journal Nature' to locate mentions of *Nature* reports, and catalogued all such citations. We traced the reference of those reports for which an author was mentioned. This resulted in a sample of 22 articles from various scientific disciplines (e.g., astronomy, vulcanology, neurobiology).

We then computed the media impact of each of these reports in the top 50 newspapers for a period of eight years after its publication in *Nature* by searching for articles that contained the last name of the first author and two key words from the report title. We then went through each article and eliminated spurious hits that did not mention the report in question. We searched for MSTP in the same way. The 10 most cited reports are shown in Table 1, along with MSTP.

Results

On average, citation rates for MSTP were 11.4 times higher than for the other reports, $t(9) = 38.1$, $p < .001$. Table 1 also shows the number of times each report was cited in 1993, the year of publication. MSTP was cited seven times in 1993, not significantly more often than the average of other reports (5.8 times), $t(9) = 1$, n.s. However, citations in 1993 are only 9% of the total number of MSTP citations, whereas they make up 90% of citations on average for the other reports, $t(9) = 6.5$, $p < .001$.

Study 1b: Tracking the diffusion of the ME over time

Method

Although MSTP received a lot of attention as a scientific report, the ME evolved beyond any link to a specific scientific report and we wanted to trace the diffusion of this broader idea. So, we enlarged our search criteria because many later articles on the ME did not mention MSTP explicitly. Our enlarged search included three search phrases: 'Mozart effect', 'Mozart and Rauscher' and 'Mozart and spatial and intelligence'. We searched the database (top 50 US newspapers) starting on the day of publication of MSTP (October 14, 1993) until July 13, 2002 (eight years and three quarters), and found 478 articles containing at least one of the search phrases. We corrected for the number of articles in the database to yield a count per million articles for each quarter.

Results

Figure 1 depicts media interest in the ME over time, along with prominent events in the genesis of the ME as a scientific legend.

Several features are worth noting. First, public events relating to the ME were accompanied by spikes in media interest. Secondly, there are qualitatively different phases in interest. Initial interest was ephemeral and tightly bound to the publication of scientific results (e.g., until 1997.3). A stable shift in media interest only occurred with events such as the publication of a pop psychology book on the ME (Campbell, 1997) or legislative action (the Georgia and Florida bills); these are all non-scientific

Table 1. Citation rates of MSTP and 10 other scientific reports. The total number of citations and number of citations in 1993 are shown

Title (publication date)	First author	Key word 1	Key word 2	No. of citations	No. of citations (1993)
Music and spatial task performance (Oct. 14)	Rauscher	music	spatial	75	7
A search for life on Earth from the Galileo spacecraft (Oct. 21)	Sagan	Galileo	spacecraft	9	7
Mechanism of the 1991 eruption of Hekla from continuous borehole strain monitoring (Oct. 21)	Linde	eruption	monitoring	9	6
The origin of Pluto's peculiar orbit (Oct. 14)	Malhotra	Pluto	Orbit	7	6
Telling tails explain the discrepancy in sexual partner reports (Sept. 30)	Morris	sexual	discrepancy	7	7
A constitutively activating mutation of the luteinizing homone receptor in familial male precocious puberty (Oct. 14)	Shenker	precocious	puberty	7	6
Spontaneous loss of T-cell tolerance to glutamic acid decarboxylase in murine insulin-dependent diabetes (Nov. 4)	Kaufman	insulin	T-cell	7	7
Dopamine D4 receptors elevated in schizophrenia (Sept. 30)	Seeman	schizophrenia	dopamine	6	6
Skin cancer and UV radiation (Nov. 4)	Madronich	cancer	radiation	6	5
Ultraviolet radiation and coral bleaching (Oct. 28)	Gleason	coral	bleaching	4	4
X larger than Y (Nov. 11)	Cui	sperm*	size*	4	4

Note. *Key word not part of original title.

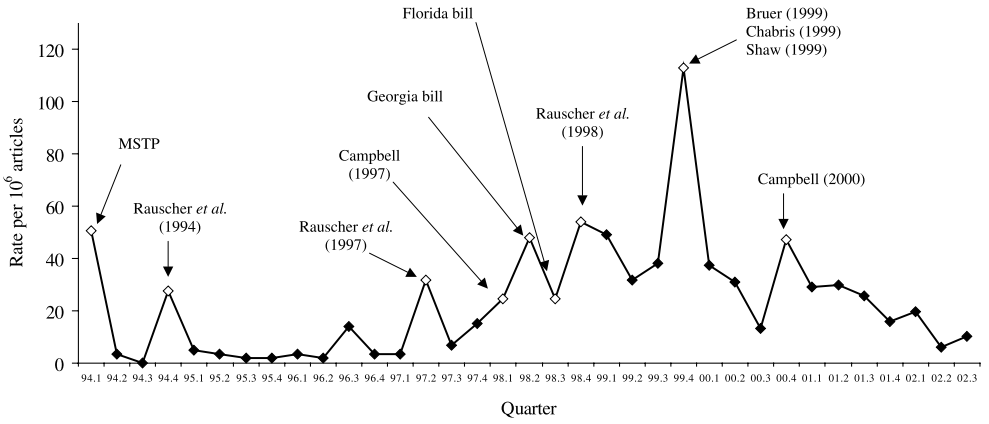

Figure 1. Media interest in the Mozart Effect by year and by quarter (expressed as number of articles per million articles). Relevant events are graphed by the quarter of their occurrence.

events. The biggest single spike of interest in the ME was generated by the publication of the meta-analysis refuting the ME (Chabris, 1999), which coincided with the release of a book by one of the authors of MSTP (Shaw, 1999) and a book debunking the widespread belief that early experience is crucial for development (Bruer, 1999). After that, there was a gradual decline of interest until the present, with the exception of 2000.4, when another pop psychology book was published (Campbell, 2000).

Discussion of Studies 1a and 1b

Media interest in MSTP surpassed interest in other reports by an order of magnitude. Moreover, media interest in MSTP persisted over time whereas the other reports were cited only during a couple of months following publication. The success of MSTP is all the more remarkable as some of the other reports had a substantial *a priori* potential for eliciting interest. Consider the report authored by Carl Sagan, a well-known astronomer, or the report on gender differences in reports of the number of sexual partners, which could have been the subject of a potentially lurid newspaper article. Why was MSTP so much more successful than these reports?

The data on the evolution of the ME shed some light on this question. In the first few years after publication of MSTP, media interest remained low, and increased only ephemerally in reaction to subsequent scientific reports. It was only when the ME manifested itself in events *outside* of science that media interest picked up, increasing in magnitude by a factor of more than 20. Thus, one can clearly distinguish two qualitatively different phases: one of transitory media interest, where articles on the ME derived from scientific reports, and one of stable interest, where articles on the ME derived from events outside of science. There was also a third phase where media interest progressively declined. This was associated with the various critical publications.

Taken together, the results of Studies 1a and 1b show some conditions under which scientific legends might emerge. Study 1a showed that MSTP elicited greater and more persistent media interest than other reports. Study 1b further showed that a stable shift in media interest occurred after the ME manifested itself in events outside of the sphere of science. In the ME's initial phase of existence, interest was transitory and did

not differ radically from other scientific reports. The question remains, however, why the ME took hold in popular culture. This is addressed in Study 2.

STUDY 2: Diffusion of the ME and anxiety about early childhood education

Previous research has repeatedly postulated that ideas spread more widely when they tap anxiety in a population. But this explanation has to our knowledge never been subjected to a systematic empirical test. By this we mean that varying rates of anxiety in different populations have never been shown to correspond to varying rates of diffusion in those populations.

We surmised that the ME was so successful because it related to a cultural preoccupation with early childhood education that is particularly prevalent in the US. This can be partly attributed to the widespread belief that the first years of life are crucial for development (Bruer, 1999; Kagan, 1998). Moreover, there is a generalized self-consciousness in the US about performance of US pupils on basic maths and science tests (e.g., 'American students still lag behind', *Seattle Times*, December 6, 2000). The US media abounds with humorous portrayals of the anxieties parents experience about the intellectual development of their children (e.g., 'Obsessive Mom', 'Mommy Guilt,' *Dallas Morning News*, October 23, 2000). As an anecdote, we note that a kindergarten near the Stanford University campus is called 'Knowledge Beginnings'. It is not labelled as a kindergarten, but as a 'childhood development center', and it advertises itself as 'preparing children for the new millennium'. A comparable institution in Switzerland (the kindergarten sponsored by the University of Neuchâtel) is called 'Vanilla-Strawberry' and makes no claims to preparing its charges for anything. We are not suggesting that this preoccupation is unique to the US, but rather that it is a prominent theme in US society.

This informal cultural diagnosis suggests that interest in the ME should be stronger in regions of the US where the quality of primary education is problematic. Such a situation may attract media attention and generate collective anxiety. We assumed that the ME suggested a way for parents and educators to solve the problem of enhancing children's intellectual development, or at least a way of taking such a task into their own hands, which may be an effective means of controlling the anxiety and feelings of helplessness generated by a deficient public education system. One columnist humorously describes the piano lessons she initiated for her children after hearing of the ME: 'After a few lessons, I stopped feeling guilty that I'd never played Mozart to help their little developing brains' (*Denver Post*, May 7, 2000).

Thus, we predicted that the ME would spread more in regions with problematic primary education. The various US states provide a natural source of regional variation on this dimension. Education in the US is funded primarily at the state and community level, and different states vary substantially in how effective they are at educating their children, in many cases because of local idiosyncrasies in educational bureaucracy (Grissmer, Flanagan, Kawata, & Williamson, 2000). We therefore sought to predict media interest in the ME from state-level measures of educational problems.

Method

There were 34 US states sufficiently represented in the database for our analyses. The other states had no newspapers in the database with complete textual content. For each of these 34 states, we computed a measure of media interest in the ME (i.e., the

Table 2. Standardized β coefficients of predictors in four ordinary least squares (OLS) regressions predicting media interest in the ME (number of ME articles per million) and percentage of variance (R^2) explained

Predictor	OLS regressions			
	1	2	3	4
Control variables				
Gross domestic product (GDP)	.22	.06	.41	.25
Population	–.02	.19	–.05	.14
Measures of concern with education				
Low teacher salary		.61**		.61**
Low national test scores and per-pupil funding			.42*	.41*
Adjusted R^2	.02	.31	.11	.46

*$p < .05$; **$p < .01$.
Note. The unit of analysis is the state ($N = 34$).

total count of ME articles per million articles over a period of eight years from October 14, 1993 to October 13, 2001). This count was obtained by dividing the total number of articles on the ME in state newspapers by the total number of articles in those newspapers and multiplying the result by one million. To get the most representative measure, we used all the state newspapers that were available in the database for each state—from one to five different newspapers per state.

We used measures of educational performance and spending in these states as proxy variables for educational problems. We collected data on the following indexes:

(1) National test scores from fourth and eighth-grade reading and maths tests in 1990 and 1992 (Grissmer *et al.*, 2000).
(2) Spending per pupil in 1990 (Grissmer *et al.*, 2000).

These variables consistently loaded together in a factor analysis, and demonstrated high multicollinearity in a regression, so we averaged ranks on each variable into a single composite (Cronbach's $\alpha = .92$).

(3) 1990 teacher salary (Census Bureau, http://www.census.gov/statab/www/ranks.html). We divided teacher salaries in each state by per capita income in that state to control for state-level differences in income.

We assumed that the lower a state ranks on these variables, the greater the level of collective anxiety with primary education in that state. We also collected data on state gross domestic product (GDP) and population. These variables were used to control for some potential confounds: states that are larger and wealthier may organize their educational system differently. The proxy and control variables were entered as predictors into four different ordinary least-squares (OLS) regression equations, with the state rank on count of ME articles per million articles as a dependent variable.

Results

Both proxy variables for educational concern emerged as significant predictors of media interest (see Table 2).

Regression 1 suggests that interest in the ME cannot be explained by the control variables. Regressions 2 and 3 show that the proxy variables were significant predictors when entered separately. The most complete regression (4), shows that states with lower teacher salaries ($\beta = .61$, $p < .01$) and low national test scores and per pupil spending ($\beta = .41$, $p < .05$) exhibit more interest in the ME.

Discussion

Measures of academic performance and spending on education predicted interest in the ME by state. If these are appropriate proxy variables for anxiety about childhood education, then we have shown that such anxiety is significantly related to the diffusion of the ME. Collective anxieties about childhood education in states with low elementary school funding and performance may have created a desire to take some kind of action to alleviate the anxiety. The ME suggests simple actions that parents can take to remove the anxiety of raising their children in a state that is experiencing problems in childhood education. To our knowledge, these results are unique in systematically relating varying rates of propagation with varying levels of concern across a population. And they support the idea that scientific legends propagate in the way that rumours and legends have been predicted to propagate.

However, although our analysis shows that interest in the ME is higher in states that are experiencing problems in childhood education, it does not directly demonstrate the role of anxiety in mediating this interest. As a result, the analysis is subject to alternate interpretations, which although possible, we believe are less likely. Perhaps, for example, states with low teacher salaries, pupil funding and test scores are filled with people who are uneducated and thus easier to sway with seemingly miraculous 'scientific' claims about the ME. But our control variables make this interpretation less likely: if a state is filled with uneducated people, we would expect average wages to be low, so this effect should be largely captured by our GDP variable. Or perhaps states with lower teacher salaries have made a conscious decision that childhood education is unimportant. In this case, our regression results would actually suggest that states with less interest and anxiety about childhood education are more interested in the ME. But even if a state has decided to be frugal in its financial expenditures, its interest in the ME is hard to explain without assuming some mediating role of anxiety: why should people be interested in a solution—even a frugal one—if they do not perceive there is a problem? The analysis in Study 3 supports the interpretation that the ME was seen as a solution to a problem by showing that its content evolved over time in a way that made it seem more suitable as a solution to the problem of childhood intellectual development. If people are more interested in the ME when they are less concerned about childhood education, then it is difficult to explain this child-focused evolution in content.

We note one other caveat: even if anxiety does increase the spread of the ME, this may not support theories that assume other kinds of rumours and legends propagate because of anxiety. The ME is unusual because it apparently offers a specific 'solution' to a pressing social problem, whereas many rumours and legends simply inform people of a problem without offering a solution. Finding that *solutions* propagate in response to anxiety is not the same as finding that *problems* do so.

STUDY 3: How the ME evolved during diffusion

In this study, we analysed how the content of the ME changed over time. As a point of comparison, recall the original scientific report (MSTP), which showed that listening to

Mozart for 10 minutes resulted in a *temporary* increase of *spatial task performance* equivalent to *8–9 IQ points* in *college students*. These limitations on the scope of the findings (duration, task domain, effect magnitude, participant population) have all been dropped in various articles. Our analysis focuses on what is perhaps the most striking overgeneralization: the shift in population from college students to children to newborns, as illustrated in the following (*Milwaukee Journal Sentinel*, July 8, 2001): 'There have been numerous studies on the "Mozart effect" and how it helps elementary students, high school students and even infants increase mental performance'. Contrary to this quote, none of these three populations have been the subject of scientific studies on the ME. To see whether this example illustrated a more general trend, we compared associations between the ME and college students, children and babies over time, using the articles sampled in the second part of Study 1b.

Method

The 478 articles in the Study 1b sample were analysed by year. For each year, the percentage of the total number of articles referring to college students, children and babies was computed. For college students, we used the search terms 'college student', 'undergraduate' and 'student'. We eliminated spurious references to students other than college students (i.e., cases where it was clear that college students were not being referred to). For children, we used the search terms 'child' or 'children'. For babies, we used the search terms 'baby', 'newborn' and 'infant'.

Results

Results are shown in Figure 2 as the percentage of total ME articles per year mentioning each population type. The original population studied, college students, showed a steadily decreasing trend in percentage of mentions from 80% in 1994 to around 30% after 2000. We calculated the correlation between percentage and year, and it was significantly negative ($r = -.79$, $p < .05$). The percentage of total articles mentioning children increased rapidly from 1994 to 1995 and fluctuated at around 80% after that ($r = .68$, $p < .05$). The percentage of total articles mentioning babies increased steadily from 0 in 1995 to 55% in 1999 and fluctuated around that level afterwards ($r = .87$, $p < .01$).

Discussion

Over time, the association between the ME and its original population, college students, decreased, whereas associations with children and babies increased. The latter two associations compose successively more extreme examples of the evolution of the original scientific finding. The association with children, which rapidly increases then stabilizes, is at least partially due to the research showing that keyboard lessons increase spatial reasoning performance in preschool children (Rauscher *et al.*, 1997). This can be considered a distortion of the original finding because the ME in its 'narrow' sense (i.e., that *listening* to classical music improves performance) has never been tested on children. This fact is confused in some articles, one of which states that MSTP showed that 'listening to brief snatches of Mozart appeared to have a short-term effect on the spatial intelligence of *preschoolers*' (*Newsday*, December 17, 1995,

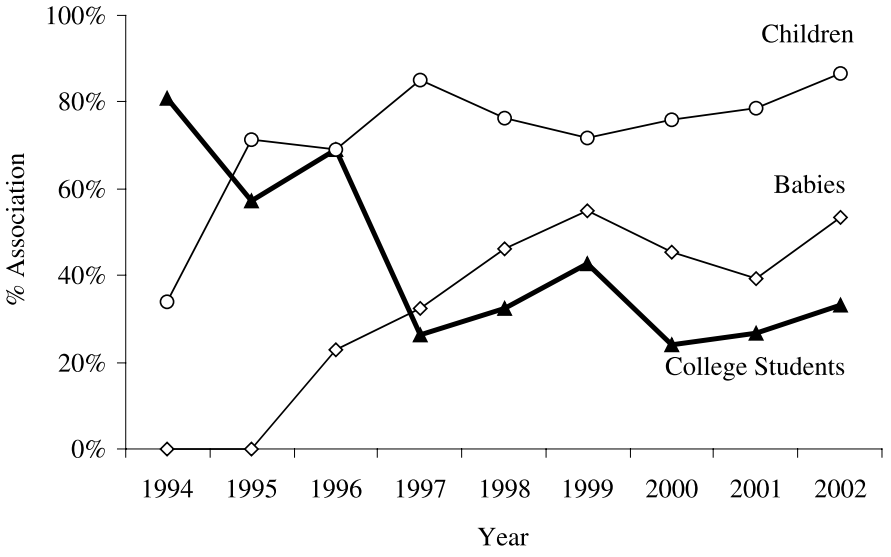

Figure 2. Trends in association of the Mozart Effect with college students, children and babies by year. Percentages of the total number of newspaper articles mentioning these populations are shown.

added italics). However, if we adapt a 'broader', more lenient definition of the ME, then both college students and children are populations that have been associated with the ME in scientific research. Interestingly, however, the legend selected only the latter population as it evolved, an effect consistent with Study 2's test of motivational factors in diffusion.

The most striking finding is the increasing association of the ME with infants. There is no scientific research whatsoever linking music and intelligence in infants, and yet, from 1997 onwards, more articles mentioned infants than college students. It should be noted that not all articles that mention infants or children erroneously report scientific research on these populations. Nevertheless, the presence of a given population in an article on the ME is a good indicator of where people perceive the ME to be most relevant.

All these transformations can be described as 'mutations' that are consistent with the culturally prevalent myth of infant determinism (Kagan, 1998) and related concern for early childhood development (Bruer, 1999). Thus, these results extend the findings of Studies 1 and 2 by showing that ideas adapt to the psychological environment of their hosts.

Interestingly, the period in which media interest in the ME shifted in magnitude (Fig. 1, 97.4–98.4) was slightly lagged in relation to the transformations of content in Figure 2 (which were most marked between 1994 and 1997). In other words, sustained media interest seemed to increase only *after* the contents were transformed. It is tempting to speculate whether such transformation is a precondition for large-scale diffusion. Moscovici (1984) suggested that unfamiliar ideas might have to be anchored in existing frames of belief in order to be communicable. Here, an analogous phenomenon may have occurred: the ME might have diffused widely only after mutations increased its relevance to ambient concerns.

GENERAL DISCUSSION

We conducted three studies of the Mozart effect to demonstrate its evolution as a scientific legend. Study 1 showed that the ME elicited far more interest than comparable reports and that it persisted for longer. However, much of this impact was delayed. A substantial shift in media interest coincided with ME-related events outside of science.

Study 2 showed that the ME was discussed more often in US states where the quality of primary education was more problematic, and hence where concern with elementary education was presumably higher. Thus, the propagation of the ME was related to the psychological environment of different host populations. These results are consistent with long-standing speculation in social representations, legend and rumour research, as well as evolutionary theories of the diffusion of ideas.

Study 3 demonstrated that the ME mutated over time. Newspaper articles overextended the scientific findings to new, untested populations. The direction of this mutation is consistent with the myth of infant determinism. This supports Moscovici's (1984) suggestion that, in order to be communicable, ideas have to be adapted to existing frames of reference. Scientific knowledge must be transformed before it can circulate widely, and a scientific legend is the end result of such a transformation.

To our knowledge, the present research is unique as a comprehensive analysis of the emergence and evolution of a scientific legend. Below, we consider some implications of our study for research on the diffusion of ideas.

The present research was based on automatic media analyses, which have the advantage of being comprehensive and objective. But these analyses must be complemented by more detailed research. Long-standing speculations about functional relationships between ideas and ambient anxieties must be studied more systematically (Jost & Ignatow, 2001). Media analyses are good field studies, but they could be combined with experimental studies manipulating variables like idea content or anxiety levels to see how they affect individuals' propensity to transmit beliefs (Heath, Bell, & Sternberg, 2001).

To conclude, we return to our initial discussion of the functionality of diffusion of ideas and speculate on some characteristics of what we call a 'life-cycle model' of the diffusion of ideas. Consider the curve of media interest shown in Figure 1. We suggested that it embodies three phases: emergence, growth and decline. These phases reflect the evolution of the functionality of the ME for its host population, but they might extend beyond the ME to characterize the evolution of other scientific legends or even other categories of beliefs.

The emergence phase constitutes the initial appearance of a scientific finding. In this phase media interest is ephemeral and it may be limited to science and technology sections of newspapers. On the other hand, reporting is likely to be most accurate. As Table 1 shows, most scientific findings do not get farther than this phase.

The growth phase begins when a scientific finding is more widely propagated because it generates interest outside of science. This interest may be reflected by the finding's appearance in more general news articles, or by embodiment in material artifacts and actions (CDs, toys, legislation and the like). A precondition for the growth phase seems to be a transformation of the finding into a form that is easier to understand and communicate to laypeople. This phenomenon is not limited to the ME. Consider the belief that consumption of red wine protects against cardiovascular

disease. It has been labelled the 'French paradox', after the finding that the French have lower levels of cardiovascular disease than Americans, despite a diet rich in fat. The French paradox diffused widely in the US after a television show reported on the subject. From a functional point of view, we might say that the widespread diffusion of a scientific legend is not unlike the phase where an innovation is adopted by an increasing number of users (Rogers, 1995). Thus, the growth phase may reflect the 'discovery' of the apparent usefulness of the ME. On the other hand, many social theorists have contended that the very act of communicating creates and reinforces social bonds (Dunbar, 1993). This factor may be particularly important in the case of the ME, especially given its anxiety-alleviating function. The diffusion of the ME may have been accelerated by the simple fact that it allowed people to talk about their shared concerns with their children's intellectual development.

The decline phase reflects diminishing media interest. Decline happens when the finding has become so well-known that it is no longer of interest; it has become 'old news', part of common knowledge. The erstwhile revolutionary finding has stabilized as a part of culture (Sperber, 1990). In this phase it may be evoked in the media as a cliché or even ridiculed: 'Remember when a study came out suggesting that classical music helps children think better, spawning a cottage industry of classical music videotapes and CDs designed to help infants, and even fetuses, think better?' (*The Plain Dealer*, September 26, 2000). We find it ironic that, only a few years after enthusiastically reporting the ME, media discourse switched to scepticism and incredulous reminiscences (e.g., 'remember when…').[3]

What leads to the decline phase? In the case of the ME, a seemingly obvious answer would be debunking by authoritative scientific research. The spike of media interest in the last quarter of 1999 (see Fig. 1) coincides with the release of several scientific publications related to the ME and directly challenging its truth. But debunking may not have to occur for an idea to decline. Instead, decline may be an almost necessary consequence of widespread diffusion. The more an idea diffuses, the more people know about it; the idea loses the novelty that gives it value as social exchange and therefore people may become less interested in communicating about it (e.g., Medalia & Larsen, 1958). This observation would suggest that instead of being a central causal factor precipitating the decline of an idea, debunking might just be one manifestation of the decline phase. The dynamics of decline suggested here resemble those described by research on clichés, words or expressions that have become stereotyped and meaningless by the very fact of their widespread use (Pickrel, 1985).

This kind of life-cycle model explicates the functional nature of widespread beliefs. It specifies the trajectory of an idea between the uncertainty, unfamiliarity and novelty that characterizes science and the mundane, cliché character of common sense. It provides a more precise formulation of the often-cited observation that social representations function to 'make the unfamiliar familiar' (Moscovici, 1984). And it captures the dynamic and regenerative character of ideas in modern society (Flick, 1998b). Moreover, it is consistent with well established findings on the diffusion of innovations (Rogers, 1995) and could be adapted to encompass phenomena of resistance to new technologies (Bauer, 1995; Wagner *et al.*, 2002). Public attitudes towards scientific findings may depend on their phase of diffusion. Attitudes in the emergence phase

[3] *We have observed this kind of rhetorical question for a number of other popular beliefs: 'Remember the French paradox?' appeared in an article on health benefits of drinking tea (Omaha World-Herald, December 12, 1998); 'Remember oat bran?' appeared in an article on health benefits of oats (CNN Online, January 6, 1995). Such an appeal to collective memory may be a rhetorical device often associated with beliefs in their decline phase.*

would be characterized by disbelief, rejection or curiosity. In the growth phase, these might switch to enthusiasm or acceptance, to be followed by scepticism and ridicule in the decline phase. A fully fledged version of this model could create a framework for comparing legends in different stages of development and maybe even different categories of belief.

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