Fraunhofer Institut
Systemtechnik und
Innovationsforschung

Biologisch inspirierte Informationstechnik - Auswertung des japanischen Delphi-Berichts 1997

Ergebnisse aus der internationalen Studie „Bioinformation – Problemlösungen für die Wissensgesellschaft“ im Auftrag des DLR (Projektträger Informationstechnik des BMBF)

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Karlsruhe, Februar 1999

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ANHANG A VERZEICHNIS DER THESEN

ANHANG B WERTE DER DELPHI-BEFRAGUNG

1 Vorbemerkung

Der japanische Delphi-Bericht ist sowohl in der Konzeption als auch in der Gestaltung und Auswahl der Thesen sowie der Fragekategorien ähnlich angelegt wie der deutsche Delphi-Bericht. Ausgewählten Experten wurden insgesamt 1072 Thesen aus 14 Themenbereichen vorgelegt, deren geschätzte Realisierungszeitpunkte möglichst nicht später als 2025 reichen sollten.

Folgende Kategorien wurden im japanischen Delphi-Bericht abgefragt:

- *Importance*: Die Experten konnten zwischen *high*, *medium*, *low* und *unnecessary* wählen. In der aggregierten Darstellung der Ergebnisse wurden die einzelnen Antworten zu einem *importance index* zusammengefaßt.
- *Expected effect*: Erwarteter Auswirkung der These auf:
  - Socioeconomic development
  - Resolution of global problems
  - People's needs
  - Expansion of intellectual resources
- *Leading countries*: Führende Länder/Ländergruppen im Forschungsgebiet:
  - USA
  - EU
  - Former Soviet Union and Eastern Europe
  - Japan
  - Others
  - Do not know
- *Measures the government should adopt*: Wichtige Maßnahmen zur Realisierung der These:
  - Foster human resources
  - Promote exchanges among industrial, academic and government sectors and different fields
  - Upgrade advanced facilities and equipment
  - Develop a research base
  - Increase government research funding
  - Adjust regulations (relax/toughen)
  - Others

- *Potential problems*: Mögliche Auswirkungen der These auf:
  - Natural environment
  - Safety
  - Morals, culture or society
  - Others

Die Thesen beziehen sich über Schlüsselbegriffe auf verschiedene Innovationsstufen:

- Elucidation
- Development
- Practical use
- Widespread use

Für die vorliegende themenbezogene Auswertung des japanischen Delphi-Berichts wurden aus allen Bereichen diejenigen Thesen ausgewählt, die einen Bezug zur Gesamtthematik „Bioinformation" haben:

- Insgesamt 136 Thesen mit Bezug zur Thematik „Bioinformation".
- Zusätzlich 23 Thesen zu herkömmlichen Speicher-/Prozessortechnologien und Sonderthemen der Forschung, die im deutschen Delphi-Bericht nur ansatzweise oder gar nicht hinterfragt sind.

Die ausgewählten 136 Thesen verteilen sich folgendermaßen auf die verschiedenen Themenbereiche:

Tabelle 1: Anzahl der Thesen pro Bereich

Nr.	**Bereich**	**Anzahl**
1	Materials & Processing	2
2	Electronics	12
3	Information	28
4	Life Sciences	34
5	Space	1
6	Marine Science & Earth Science	4
7	Resources & Energy	1
8	Environment	0
9	Agriculture, Forestry & Fisheries	4

10	Production & Machinery	13
11	Urbanization & Construction	2
12	Communications	11
13	Transportation	7
14	Health, Medical Care & Welfare	17

Die ausgewählten Thesen wurden schließlich entsprechend der in der themenbezogenen Auswertung des deutschen Delphi-Berichts vorgenommenen Gruppierung neu zusammengestellt, um einen Vergleich zu ermöglichen. Aufgrund der größeren Anzahl der Thesen im japanischen Delphi-Bericht war teilweise eine Verfeinerung der Strukturierung in Unterkapitel möglich. Die Originalthesen sind nach folgender Ordnung in Anhang A gelistet:

1 Bio-/Humanwissenschaftliche Grundlagenforschung
1.1 Meß- und Untersuchungsmethoden
1.2 Aufklärung molekularer Prozesse
1.2.1 Allgemeine Thesen zu molekularen Prozessen
1.2.2 Immunsystem
1.2.3 Nervensystem
1.3 Komplexe kognitive Prozesse
1.4 Entstehung von Leben
1.5 Evolution und Phylogenese
1.6 Ontogenese

2 Hybride Systeme
2.1 Hybride Hardware
2.1.1 Allgemeine Thesen zu Biocomputern
2.1.2 Hybride Hardware auf molekularer Ebene
2.1.3 Hybride Hardware auf zellulärer Ebene
2.1.3.1 Chip/Zell-Interface
2.1.3.2 Künstliche Nervensysteme
2.1.4 Hybride Hardware auf Organ-/Organismus-Ebene
2.2 Biomolekulare Speicher
2.3 Biosensorik
2.4 Implantate/künstliche Organe
2.4.1 Implantierte Mikromaschinen
2.4.2 Künstliche Bewegung von Gliedmaßen/Muskeln
2.4.3 Künstliche innere Organe
2.4.3.1 Allgemeine Thesen zur Verbreitung von Implantaten
2.4.3.2 Cochlea

2.4.3.3 Cornea
2.4.3.4 Endokrine Organe
2.4.3.5 Blase
2.4.3.6 Lunge
2.4.3.7 Herz
2.4.3.8 Niere

3 Bioanaloge Basistechnologien
3.1 Bioanaloge Hardware
3.1.1 Allgemeine Thesen zu Selbstorganisations-/Regenerations-/Reproduktionsfähigkeit
3.1.2 Analogie zu zellulären Prozessen
3.1.3 Neural-Computers
3.1.4 Automatisches Chipdesign
3.2 Anpassungsfähige Software
3.3 Künstliche Intelligenz/Nachbildung komplexer kognitiver Leistungen[1]

4 Robotik
4.1 Bau- und Wartungsroboter
4.2 Versorgungs- und Unterstützungsroboter
4.2.1 Roboter im Pflege- und Gesundheitsbereich
4.2.2 Haushaltsroboter
4.3 Roboter für Sicherheit und Katastrophenschutz
4.4 Landwirtschaftsroboter
4.5 Roboter zur Rohstoffgewinnung
4.6 Unbemannte Fahrzeuge
4.7 Allgemeine Thesen zu Intelligenz und Aktorik

5 Mensch-Maschine-Schnittstelle
5.1 Sprachverarbeitung
5.1.1 Sprachsynthese
5.1.2 Spracherkennung
5.1.3 Multimodale Kommunikation
5.1.4 Sprachübersetzung
5.1.5 Übertragung von Willen in Sprache
5.2 Optische Mustererkennung
5.3 Intelligentes Datenbankmanagement

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[1] Im folgenden analog zur Auswertung des deutschen Delphi-Berichts als „Künstliche Intelligenz" bezeichnet.

5.4 Agententechnologien
5.5 Lern-/Wahrnehmungsunterstützende Darstellungsformen
5.6 Pädagogische Methoden

6 Herkömmliche IT
6.1 Herkömmliche Prozessortechnologien
6.2 Herkömmliche Speichertechnologien

7 Sonderthemen
7.1 Evolutionäre Strategien in der Biotechnologie
7.2 Molekulare Elektronik
7.3 Multi-Prozessor-Systeme
7.4 Intelligente Netzfunktionen
7.5 Software-Recycling und -Verifikation

2 „Bioinformation“ als zukunftsträchtiges FuE-Feld?

Im folgenden werden die Ergebnisse der themenbezogenen Auswertung dem Gesamtergebnis des japanischen Delphi-Berichts gegenübergestellt. Da nur eine manuelle Auswertung möglich war, wurden nicht alle Antwort-Kategorien systematisch analysiert. Die Teilgebiete in den nachfolgenden Tabellen entsprechen den Kapiteln in Anhang A, sofern nicht anders vermerkt (vgl. auch Anhang B).

2.1 Realisierungszeiträume

Zu jeder These konnten die Experten zwischen verschiedenen Realisierungszeiträumen wählen: Bis zum Jahre 2000, 2001 bis 2005, 2006 bis 2010, 2011 bis 2015, 2016 bis 2020, 2021 bis 2025, nach 2025 oder nie. Zusätzlich konnte eine „weiß nicht“-Kategorie angekreuzt werden. Die im folgenden genannten Realisierungszeitpunkte entsprechen, wenn nicht anderes vermerkt, dem Median aller Angaben[2].

Die zeitliche Verteilung der Realisierungszeiträume für die ausgewählten Thesen ist gegenüber der den gesamten Delphi-Bericht umfassenden Auswertung deutlich zu späteren Zeitpunkten hin verschoben. Während die Gesamtbetrachtung einen Höhepunkt der Innovationsdynamik um das Jahr 2010 reflektiert, liegt die „Hochphase“ von Innovationen im Bereich der „Bioinformation“ um etwa 2015. Einer weitaus höheren Zahl von Thesen wird eine Realisierung sogar erst in den Zeiträumen 2016-2020 bzw. 2021-2025 zugetraut. Diese Gesamttendenz ist auch im deutschen Delphi-Bericht festzustellen.

Tabelle 2: Verteilung der Realisierungszeitpunkte (Mediane)

Zeitraum	gesamter Delphi-Bericht	Thesen zu „Bioinformation“
1996 - 2000	0,0 %	0,0 %
2001 - 2005	4,2 %	2,2 %
2006 - 2010	37,1 %	20,6 %
2011 - 2015	38,0 %	44,1 %
2016 - 2020	15,3 %	24,3 %
2021 - 2025	4,7 %	8,1 %
2026 -	0,7 %	0,7 %

2 Die Kategorien „nie“ und „weiß nicht“ wurden dabei nicht berücksichtigt.

Tabelle 3: Innovationsschübe in ausgewählten FuE-Gebieten

FuE-Gebiet	**Erstes Quartil**	**Mittelwert d. Mediane**	**Letztes Quartil**
Bio-/Humanwissenschaftliche Grundlagenforschung			
Immunsystem	2011	2015	2019
Nervensystem	2012	2017	2022
Komplexe kognitive Prozesse	2014	2020	2022
Entstehung von Leben	2020	2024	>2025
Phylogenese	2013	2020	>2025
Ontogenese	2017	2022	>2025
Hybride Systeme			
Hybride Hardware auf molek. Ebene	2012	2017	2022
Chip/Zell-Interface	2012	2016	2021
Künstliche Nervensysteme	2015	2019	>2025
Hyb. H. auf Organ/Organismus-Ebene	2018	2023	>2025
Biomolekulare Speicher	2012	2015	2022
Biosensorik	2007	2012	2017
Implantate (künstl. innere Organe)	2010	2015	2021
Bioanaloge Basistechnologien			
Reproduktionsfähige Artefakte	2014	2018	2023
Neural-Computers	2012	2017	2023
Automatisches Chipdesign	2009	2014	2018
Anpassungsfähige Software	2009	2013	2018
Künstliche Intelligenz	2014	2019	2024
Robotik			
Bau- und Wartungsroboter	2008	2011	2016
Roboter im Pflege/Gesundheitsbereich	2008	2012	2016
Haushaltsroboter	2011	2016	2021
Landwirtschaftsroboter	2007	2010	2015
Unbemannte Fahrzeuge	2007	2011	2016
Mensch-Maschine-Schnittstelle			
Sprachverarbeitung	2007	2011	2015
Optische Mustererkennung	2006	2009	2014
Intelligentes Datenbankmanagement	2007	2010	2014
Agententechnologien	2003	2006	2010

Herkömmliche Informationstechnik			
Herkömmliche Prozessortechnologien	2010	2014	2018
Herkömmliche Speichertechnologien	2011	2015	2020
Sonderthemen			
Molekulare Elektronik	2012	2017	2022
Multi-Prozessor-Systeme	2009	2012	2016
Intelligente Netzfunktionen	2004	2007	2011
Software-Recycling und -Verifikation	2006	2009	2014

In Tabelle 3 wurden für die verschiedenen FuE-Gebiete die im Delphi-Bericht ermittelten „Innovationsschübe" aufgelistet. Dazu wurden jeweils die Werte für das erste Quartil als Indiz für die beginnende Innovationsphase gewählt, der Mittelwert aller Mediane der zum Gebiet gehörenden Thesen als Indiz für die „Boomphase" und die Werte für das letzte Quartil als Indiz für den in den Thesen reflektierten „Ausklang".

Die Tabelle zeigt einen sowohl zwischen den Bereichen als auch unter den FuE-Gebieten eines Bereiches deutlich unterschiedlichen zeitlichen Verlauf der Innovationstätigkeit. In allen anwendungsorientierten Bereichen (Hybride Systeme etc.) sind Teilgebiete mit mittelfristigem Anwendungspotential sichtbar. Besonders optimistisch werden jeweils die Gebiete Biosensorik (im Bereich Hybride Systeme), Automatisches Chipdesign und Anpassungsfähige Software (Bioanaloge Basistechnologien), Landwirtschaftsroboter und Unbemannte Fahrzeuge (Robotik) und und Agententechnologien (Mensch-Maschine-Schnittstelle) beurteilt.

Im Gegensatz zu anwendungsbezogenen Bereichen herrscht bei der Beurteilung von „Durchbrüchen" in der bio-/humanwissenschaftlichen Grundlagenforschung sowohl in der japanischen als auch in der deutschen Umfrage Zurückhaltung. Hier werden wichtige Innovationen wesentlich später erwartet.

2.2 Wichtigkeit der Thesen

Zu jeder These konnten die Experten ein Urteil über deren Wichtigkeit für verschiedene Bereiche abgeben. Hierzu diente zum einen ein integraler Wert, der die generelle Wichtigkeit der These für Japan ausdrücken soll. Es wurde zwischen den Kategorien *high, medium, low importance* sowie *unnecessary* unterschieden und ein gewichteter Mittelwert gebildet (*importance index*).

Des weiteren wurde die Frage nach der Relevanz jeder These für die Bereiche *socioeconomic development, resolution of global problems, people's needs* und *expansion of intellectual resources* gestellt. Mehrfachnennungen waren möglich, die in prozentualen Anteilen resultierten.

Die Tabellen 4 und 5 zeigen die Ergebnisse für Teilbereiche des japanischen Delphi-Berichts. Aufgrund der Heterogenität der Thesen zum Bereich „Bioinformation", die teilweise stark schwankende Werte zur Folge hat, folgt eine detaillierte Analyse dieses Themenkomplexes in Tabelle 6. Auf eine kumulierte Darstellung wie in den Tabellen 4 und 5 wird aus eben diesem Grund verzichtet.

Tabelle 4: Einschätzung der Wichtigkeit (*importance index*) der Thesen nach Delphi-Teilbereichen

	importance index
Bereich *Electronics*	67,7
Bereich *Information*	62,4
Bereich *Life Science*	66,1
Bereich *Production*	64,5
Bereich *Health*	61,5
Durchschnitt Delphi-Studie	62,1

Tabelle 5: Einschätzung der Wirkung der Thesen[3]

	Socioecon. development	***Resolution of global problems***	***People's needs***	***Expansion of intellectual resources***
Bereich *Electronics*	78	8	33	20
Bereich *Information*	64	8	60	17
Bereich *Life Science*	32	23	50	36
Bereich *Production*	67	29	35	14
Bereich *Health*	33	2	92	18
Durchschnitt Delphi-Studie	50	33	42	18

3 Anzahl der Fälle, in denen die jeweilige Antwort-Kategorie angekreuzt wurde in Prozent.

Tabelle 6 zeigt sowohl den *importance index* als auch die Wirkung der jeweiligen Thesen bzw. Thesengruppierungen auf das *socioeconomic development.* Letztere ist mit dem *importance index* stark korreliert, im Gegensatz beispielweise zu der Forderung nach der Lösung globaler Probleme o. ä. Die Gruppierung der Thesen folgte der Auswertung des deutschen Delphi-Berichtes, um eine möglichst gute Vergleichbarkeit herzustellen.

Tabelle 6: Detaillierte Darstellung der Wichtigkeit und Wirkung der Thesen zur „Bioinformation"

FuE-Gebiet	***importance index***[4]	**Wirkung auf *socioeconomic development***
Bio-/Humanwissenschaftliche Grundlagenforschung		
Immunsystem	74	11
Nervensystem	64	24
Komplexe kognitive Prozesse	63	20
Entstehung von Leben	50	4
Phylogenese	46	3
Ontogenese	71	10
Hybride Systeme		
Hybride Hardware auf molek. Ebene	60	75
Chip/Zell-Interface	58	43
Künstliche Nervensysteme	60	60
Hyb. H. auf Organ/Organismus-Ebene	62	49
Biomolekulare Speicher	82	88
Biosensorik	59	50
Implantate (künstl. innere Organe)	64	37
Bioanaloge Basistechnologien		
Reproduktionsfähige Artefakte	62	72
Neural-Computers	67	85
Automatisches Chipdesign	76	95
Anpassungsfähige Software	61	74

4 Der *importance index* und der Prozentwert „Wirkung auf *socioeconomic development*" zu den einzelnen Thesen ist in Anhang B zu finden.

Künstliche Intelligenz	53	59
Robotik		
Bau- und Wartungsroboter	61	80
Roboter im Pflege/Gesundheitsbereich	62	24
Haushaltsroboter	46	42
Landwirtschaftsroboter	51	53
Unbemannte Fahrzeuge	55	54
Mensch-Maschine-Schnittstelle		
Sprachverarbeitung	63	60
Optische Mustererkennung	59	60
Intelligentes Datenbankmanagement	60	80
Agententechnologien	64	69
Herkömmliche Informationstechnik		
Herkömmliche Prozessortechnologien	85	93
Herkömmliche Speichertechnologien	85	93
Sonderthemen		
Evol. Strategien in der Biotechnol.	61	66
Molekulare Elektronik	68	76
Multi-Prozessor-Systeme	65	84
Intelligente Netzfunktionen	71	88
Software-Recycling und -Verifikation	82	91

Zur besseren Übersicht werden im folgenden die Teilbereiche aus Tabelle 6 sortiert nach Wichtigkeit und Wirkung dargestellt. Zu betonen bleibt, daß die bio-/humanwissenschaftliche Grundlagenforschung durchgehend anders beurteilt wird als anwendungsnähere Themenbereiche. Ihr wird beispielsweise eine deutlich geringere Bedeutung auf das *socioeconomic development* zugesprochen, was wohl hauptsächlich auf die wesentlich weiter in der Zukunft liegenden Realisierungszeitpunkte zurückzuführen ist. Aus diesem Grund werden die Grundlagenforschung und die computerwissenschaftliche Forschung und Entwicklung in den nachfolgenden Tabellen getrennt betrachtet.

Tabelle 7: Gebiete der bio-/humanwissenschaftlichen Grundlagenforschung sortiert nach dem Wert des *importance index*:

FuE-Gebiet	***importance index***
Immunsystem	74
Ontogenese	71
Nervensystem	64
Komplexe kognitive Prozesse	63
Entstehung von Leben	50
Phylogenese	46
Durchschnitt Delphi-Studie	62,1

Tabelle 8: Gebiete der bio-/humanwissenschaftlichen Grundlagenforschung sortiert nach der Wirkung auf *socioeconomic development*:

FuE-Gebiet	**Wirkung auf *socioeconomic development***
Nervensystem	24
Komplexe kognitive Prozesse	20
Immunsystem	11
Ontogenese	10
Entstehung von Leben	4
Phylogenese	3
Durchschnitt Delphi-Studie	50

Tabelle 9: Computerwissenschaftliche FuE-Gebiete und Sonderthemen sortiert nach dem Wert des *importance index*:

FuE-Gebiet	***importance index***
Herkömmliche Prozessortechnologien	85
Herkömmliche Speichertechnologien	85
Biomolekulare Speicher	82
Software-Recycling und -Verifikation	82
Automatisches Chipdesign	76
Intelligente Netzfunktionen	71
Molekulare Elektronik	68
Neural-Computers	67
Multi-Prozessor-Systeme	65

Implantate (künstl. innere Organe)	64
Agententechnologien	64
Sprachverarbeitung	63
Hyb. H. auf Organ/Organismus-Ebene	62
Reproduktionsfähige Artefakte	62
Roboter im Pflege/Gesundheitsbereich	62
Anpassungsfähige Software	61
Bau- und Wartungsroboter	61
Evol. Strategien in der Biotechnol.	61
Hybride Hardware auf molek. Ebene	60
Künstliche Nervensysteme	60
Intelligentes Datenbankmanagement	60
Biosensorik	59
Optische Mustererkennung	59
Chip/Zell-Interface	58
Unbemannte Fahrzeuge	55
Künstliche Intelligenz	53
Landwirtschaftsroboter	51
Haushaltsroboter	46
Durchschnitt Delphi-Studie	62,1

Tabelle 10: Computerwissenschaftliche FuE-Gebiete und Sonderthemen sortiert nach der Wirkung auf *socioeconomic development*:

FuE-Gebiet	**Wirkung auf *socioeconomic development***
Automatisches Chipdesign	95
Herkömmliche Prozessortechnologien	93
Herkömmliche Speichertechnologien	93
Software-Recycling und -Verifikation	91
Biomolekulare Speicher	88
Intelligente Netzfunktionen	88
Neural-Computers	85
Multi-Prozessor-Systeme	84
Bau- und Wartungsroboter	80
Intelligentes Datenbankmanagement	80

Molekulare Elektronik	76
Hybride Hardware auf molek. Ebene	75
Anpassungsfähige Software	74
Reproduktionsfähige Artefakte	72
Agententechnologien	69
Evol. Strategien in der Biotechnol.	66
Sprachverarbeitung	60
Künstliche Nervensysteme	60
Optische Mustererkennung	60
Künstliche Intelligenz	59
Unbemannte Fahrzeuge	54
Landwirtschaftsroboter	53
Biosensorik	50
Hyb. H. auf Organ/Organismus-Ebene	49
Chip/Zell-Interface	43
Haushaltsroboter	42
Implantate (künstl. innere Organe)	37
Roboter im Pflege/Gesundheitsbereich	24
Durchschnitt Delphi-Studie	50

Ein Vergleich der Wirkung der einzelnen FuE-Gebiete auf das *socioeconomic development* mit den entsprechenden Werten aus der deutschen Delphi-Befragung, wo nach der Bedeutung für die wirtschaftliche Entwicklung gefragt wird, ist in Tabelle 11 dargestellt. Es gilt hierbei zu beachten, daß die FuE-Gebietsbezeichnungen aus der deutschen Studie übernommen wurden und deshalb einzelne Unterpunkte aus Tabelle 6 zusammengefaßt sind. Dies wird ggf. durch Fußnoten gekennzeichnet.

Tabelle 11: Vergleich zwischen japanischer und deutscher Delphi-Studie hinsichtlich der Wirkung der FuE-Gebiete auf das *socioeconomic development* [5]

FuE-Gebiet	**Japan**	**Deutschland**
Hybride Hardware auf molekularer Ebene	75	78
Hybride Hardware auf zellulärer Ebene[6]	52	35
Hybride Hardware auf Organ/Organismus-E.	49	51

[5] Anzahl der Fälle, in denen die jeweilige Antwort-Kategorie angekreuzt wurde in Prozent.

[6] Im japanischen Bericht „Chip/Zell-Interface" und „Künstliche Nervensysteme" (Mittelwert).

Biomolekulare Speicher	88	90
Biosensorik	50	63
Implantate	37	34
Bioanaloges Chipdesign[7]	90	92
Anpassungsfähige Software	74	70
Künstliche Intelligenz	59	60
Roboter für Bau- und Wartungsarbeiten	80	85
Versorgungs- und Unterstützungsroboter[8]	33	33
Sprachverarbeitung	60	66
Optische Mustererkennung	60	56
Intelligentes Datenbankmanagement	80	75
Agententechnologien	69	72

Es ist eine sehr gute Übereinstimmung zwischen den Beurteilungen der japanischen und deutschen Experten erkennbar.

2.3 FuE-Stand

In einer Kategorie der Delphie-Studie wurde nach dem Land gefragt, dessen FuE-Bemühungen um eine Realisierung der jeweiligen Zukunftsvision am weitesten sind. Den Vergleich der Werte für einige Bereiche des japanischen Delphi-Berichts zeigt Tabelle 12. Auch hier wurde wegen der manuellen Auswertung ein spezieller Mittelwert zur „Bioinformation" nicht bestimmt. Trotzdem läßt sich insgesamt ein qualitativer Vergleich mit der deutschen Delphi-Studie anstellen. In den entscheidenden Forschungsbereichen *Electronics, Information* und *Life Science* sehen auch die japanischen Experten die USA als führend an, wenn auch nicht in dem Maße, wie dies bei der deutschen Befragung der Fall war. Japan schneidet im Vergleich zum deutschen Delphi-Bericht etwas besser ab, die EU dagegen deutlich schlechter.

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[7] Im japanischen Bericht „Neural Computers" und „Automatisches Chipdesign" (Mittelwert).

[8] Im japanischen Bericht „Haushaltsroboter" und „Landwirtschaftsroboter" (Mittelwert).

Tabelle 12: Die Japanische FuE-Position im internationalen Vergleich[9]

	USA	**EU**	**Japan**
Bereich *Electronics*	43,7	10,9	40,1
Bereich *Information*	49,8	11,3	32,6
Bereich *Life Science*	49,3	21,1	24,5
Bereich *Production*	41,1	14,1	31,7
Bereich *Health*	48,0	18,3	26,1
Durchschnitt Delphi-Studie	41,3	15,7	32,3

2.4 Folgeprobleme

Als weitere Antwortkategorie konnten die Experten Folgeprobleme benennen, die ihnen im Falle einer Realisierung wahrscheinlich erscheinen.

Tabelle 13: Beurteilung von Folgeproblemen in Japan[10]

	Natural environment	***Safety***	***Morals, culture or society***
Bereich *Electronics*	2	5	8
Bereich *Information*	1	23	27
Bereich *Life Science*	11	8	22
Bereich *Production*	10	15	13
Bereich *Health*	1	17	38
Durchschnitt Delphi-Studie	15	13	13

9 Anzahl der Fälle, in denen die jeweilige Antwort-Kategorie angekreuzt wurde in Prozent. Die Angaben sind dabei so normiert, daß sie sich zu hundert addieren. Die zu 100 % fehlenden Prozente entfallen auf die Kategorien *Former Soviet Union and Eastern Europe* sowie *Others*.

10 Anzahl der Fälle, in denen die jeweilige Antwort-Kategorie angekreuzt wurde in Prozent.

Bei der Einschätzung von Folgeproblemen zeigt sich ein recht uneinheitliches Bild. Auffällig sind die genannten gesellschaftlich-moralischen Probleme, die sich aus Innovationen im Gesundheitsbereich (*Health*) ergeben, und verstärkte Nennungen bei den Auswirkungen des Informations-Bereichs auf Sicherheit und Gesellschaft. Ein Vergleich mit der deutschen Delphi-Auswertung offenbart jedoch erhebliche Unterschiede bei der Einschätzung von Folgeproblemen. Die deutschen Experten sehen fast durchgehend gesellschaftlich-kulturelle Probleme bei der Realisierung von Forschungsthemen zur "Bioinformation" mit Durchschnittswerten von 90 % der Nennungen. Auch die Sicherheitsproblematik wird hier als wesentlich gravierender eingeschätzt. Auswirkungen auf die Umwelt spielen in beiden Delphi-Auswertungen praktisch keine Rolle.

Anhang A: Verzeichnis der Thesen

Verzeichnis der Originalthesen des japanischen Delphiberichts (geordnet nach F&E-Gebieten)

Lesehilfe:

Da der japanische Delphibericht nicht in elektronischer Form vorlag, wurde die Auswahl und Neuordnung sowie die Auswertung der Thesen auf "traditionelle" Weise vorgenommen.

Die Zahlenangaben, die jeder These vorangestellt sind, beziehen sich auf die Nummer des Bereichs (1. Zahl, vgl. Tabelle 1) bzw. die laufende Nummer innerhalb des Bereichs (2. Zahl) im Originalbericht. Die Zahl in der Mitte ist die laufende Nummer der themenbezogenen Auswertung. Auf diese Zahlen wird im Text bzw. im Anhang B (Verzeichnis der Werte) Bezug genommen.

Die erste Zeile jeder These gibt die Ergebnisse der ersten Runde der Delphi-Befragung wieder. Ausgewertet wurde in vorliegendem Bericht nur jeweils die zweite Zeile (zweite Runde der Befragung). Die dritte Zeile erfaßt die Aussagen aus der zweiten Befragungs-Runde der im entsprechenden FuE-Gebiet aktiven Experten mit hoher Fachkenntnis.

Die Darstellung der Realisierungszeiträume entspricht der des deutschen Delphi-Berichts[1].

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[1] Grau unterlegte "Häuschen": Ergebnisse der zweiten Runde.
Die Ergebnisse für die Realisierungszeiträume aus der zweiten Runde sind aufgrund der Konvergenz der Meinungen in allen vorliegenden Fällen enger eingegrenzt als die der ersten Runde.

1 Bio-/Humanwissenschaftliche Grundlagenforschung

1.1 Meß- und Untersuchungsmethoden

1.2 Aufklärung molekularer Prozesse

1.2.1 Allgemeine Thesen zu molekularen Prozessen

1.2.2 Immunsystem

1.2.3 Nervensystem

1.3 Komplexe kognitive Prozesse

1.4 Entstehung von Leben

1.5 Evolution und Phylogenese

1.6 Ontogenese

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%)			Importance (index, %)					Expected effect (%)			
					High	Medium	Low	Index	High	Medium	Low	Unnecessary	Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources

Division	Topic serial No.	Forecasted realization time (2001, 2006, 2011, 2016, 2021, 2026)							Leading countries (%)						Measures the government should adopt (%)							Potential problems (%)			
								Will not be realized (%)	Do not know (%)	USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax toughness)	Others	Adverse effect on the natural environment	Adverse effect on society	Adverse effect on morals, culture or society	Other adverse effects

1.1 Meß- und Untersuchungsmethoden

4	34	Development of experimental techniques for recording and analyzing the activities of a large numbers of neurons simultaneously and over a long period of time.	1	145	15	30	55	68	41	18	11	0	22	2	56	68	1	2	10	79	34	0	40	1	11	72	37	35	1	62	0	1	1	3	15	1
			2	118	11	29	58	65	34	56	9	0	21	1	56	76		2	7	84	30	0	39	0	11	79	33	30	0	64	0	1	0	3	20	0
			X	16	100	0	0	81	63	38	0	0	31	0	50	75		0	0	100	50	0	63	0	0	81	44	50	0	56	0	6	0	0	25	0

1.2.1 Allgemeine Thesen zu molekularen Prozessen

4	41	Elucidation of relationships between higher-order structures and functions of the nuclei in eukaryotic cells.	1	229	17	36	48	57	26	51	22	2	5	7	90	87	2	12	84	48	1	31	0	11	75	21	27	14	61	0	0	3	4	10	3
			2	190	15	34	51	54	19	61	19	1	3	3	95	93		2	7	91	52	0	31	0	7	82	13	21	8	66	1	0	3	3	13	2
			X	27	100	0	0	72	46	50	1	0	0	0	15	100		0	4	100	70	0	33	0	0	85	11	26	19	63	4	0	4	4	19	0
4	20	Complete elucidation of the molecular mechanism explaining the cell cycle in higher order mammals (humans, mice)	1	218	18	29	44	62	35	44	20	2	13	6	53	76	3	6	93	54	1	42	0	5	73	19	23	21	63	1	0	4	4	17	2
			2	205	16	31	50	61	31	52	16	1	8	3	19	83		1	6	95	57	0	46	0	2	80	10	22	14	67	0	0	2	2	19	0
			X	33	100	0	0	88	75	25	0	0	6	9	61	88		0	0	100	73	0	58	0	0	88	6	42	9	82	0	0	0	6	18	0
4	8	Elucidation of the molecular structure of apotosys, making it possible to create and remove cells at will.	1	265	23	32	45	64	38	44	17	1	15	3	72	57	11	12	88	35	0	40	1	6	66	32	22	17	56	3	0	6	9	30	2
			2	209	22	32	46	65	35	52	12	0	10	2	78	56		9	8	91	37	0	47	0	5	75	30	14	10	63	3	0	4	7	33	1
			X	16	100	0	0	78	57	41	2	0	17	1	80	65		9	4	100	52	0	67	0	0	89	35	17	11	74	4	0	4	4	26	0
4	45	Elucidation of the entire molecular mechanisms of the construction of cytoskeleton in plants.	1	147	9	34	57	50	18	19	29	4	15	14	4	69	1	12	71	44	0	29	0	15	66	15	23	13	50	1	0	10	1	3	2
			2	114	10	27	63	49	13	37	29	1	11	46	0	79	1	6	82	45	0	28	0	15	79	11	18	7	58	0	0	17	0	1	0
			X	11	100	0	0	64	27	73	0	0	18	45	0	82		0	0	82	64	0	55	0	0	82	0	27	9	64	0	0	9	0	0	0
4	44	Elucidation of the entire molecular mechanisms of signal transduction in plants, from the perception of external signal such as low temperature, to the phenotypic expression such as cold resistance.	1	171	15	35	49	62	31	56	11	2	29	82	6	50	1	9	74	44	1	39	1	17	67	27	25	22	57	1	0	29	2	4	2
			2	134	15	30	55	63	27	70	3	0	25	65	1	47	1	5	81	49	0	46	1	10	78	25	22	14	64	1	0	32	1	2	1
			X	20	100	0	0	78	55	15	0	0	50	50	0	65		0	5	85	65	0	55	5	0	75	15	45	10	70	0	0	45	0	0	0
4	82	Elucidation of the entire molecular mechanisms which generate the internal rhythms in organisms.	1	177	7	29	63	53	22	45	31	2	11	11	51	71	2	10	72	40	1	29	0	16	68	22	22	10	53	0	0	7	2	14	3
			2	115	3	33	64	50	15	55	27	2	8	6	47	75	1	3	82	39	1	23	0	12	82	17	19	6	57	0	0	3	2	21	1
			X	4	100	0	0	38	0	75	0	25	0	0	50	75	0	0	100	25	0	50	0	0	75	0	50	0	100	0	0	0	0	25	0

1.2.2 Immunsystem

4	27	Elucidation of the immune mechanisms which distinguish between "self" and "not self".	1	228	14	34	52	70	45	45	9	0	14	3	80	58	2	4	91	53	0	46	0	4	72	24	26	17	61	1	0	2	11	18	3
			2	198	11	32	57	70	42	54	5	0	8	2	83	61	1	2	96	55	0	46	0	2	79	14	23	10	67	1	1	2	8	22	1
			X	22	100	0	0	86	73	27	0	0	23	0	82	82	0	0	100	64	0	68	0	0	95	32	9	9	82	5	0	5	0	14	5
4	71	Elucidation of the mutual regulatory mechanisms of the immune system, nervous system, and endocrine system, and utilization of such knowledge in the treatment of disease and promotion of health.	1	196	14	37	49	75	51	41	5	1	19	1	92	36	2	7	84	48	0	46	1	10	68	38	28	12	64	1	0	2	8	18	2
			2	165	10	39	50	78	57	41	1	0	13	1	96	35	1	3	90	50	0	46	1	7	76	38	21	7	65	1	0	2	7	21	1
			X	17	100	0	0	88	76	24	0	0	29	12	100	59	0	0	88	53	0	76	0	0	82	47	12	12	82	0	0	6	12	18	0

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%)			Importance (index, %)					Expected effect (%)			
					High	Medium	Low	Index	High	Medium	Low	Unnecessary	Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources

Forecasted realization time (2001, 2006, 2011, 2016, 2021, 2025)			Leading countries (%)						Measures the government should adopt (%)							Potential problems (%)			
	Will not be realized (%)	Do not know (%)	USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relaxed/tightened)	Others	Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects

1.2.3 Nervensystem

4	63	Elucidation of the molecular mechanisms for formation of neuronal networks at the molecular level.	1	159	11	31	58	66	37	53	8	1	16	0	0	74	10	3	6	86	45	0	39	0	9	72	25	35	10	62	1	0	1	6	13	2
			2	130	7	28	65	64	30	65	5	0	9	0	62	52		0	5	92	45	0	36	0	3	78	17	28	5	64	0	0	1	6	15	0
			X	9	100	0	0	94	89	11	0	0	33	0	44	89		0	0	89	56	0	44	0	0	78	0	33	0	56	0	0	0	0	11	0
1	72	Elucidation of the information transmission structure of sensory nerves.	1	106	5	13	82	63	31	59	9	1	52	5	56	70	11	2	4	74	45	5	42	1	20	64	39	22	16	47	0	0	1	7	15	3
			2	89	2	11	87	65	33	61	7	0	54	2	60	69		1	1	84	49	1	42	1	16	79	43	16	11	58	0	1	2	3	22	1
			X	2	100	0	0	100	100	0	0	0	50	0	50	50		0	0	100	50	0	50	0	0	50	50	0	0	100	0	0	0	0	50	0
4	66	Elucidation of the whole molecular mechanisms for synaptic plasticity in the mammalian brain. (e.g. hippocampal long-term potentiation and depression).	1	139	9	29	62	64	36	52	11	1	8	1	51	71	12	4	6	81	40	1	42	0	13	71	25	37	7	67	0	0	1	7	14	1
			2	117	5	30	65	63	30	60	9	0	8	1	51	80		5	5	89	39	0	43	0	5	77	16	30	2	68	0	0	1	3	18	1
			X	6	100	0	0	92	83	17	0	0	33	0	50	67		0	0	100	50	0	33	0	0	100	0	67	0	100	0	0	0	0	17	0

1.3 Komplexe kognitive Prozesse

4	64	Elucidation of relationship between learning/memory and synapic plasticity.	1	153	10	31	58	68	41	50	9	1	16	0	58	75	13	2	6	86	42	1	42	0	8	73	27	37	7	61	1	0	0	8	20	2
			2	126	8	29	63	68	39	56	5	0	10	0	78	81		0	2	92	41	1	39	0	2	79	18	31	2	64	0	0	0	5	21	1
			X	10	100	0	0	95	90	10	0	0	30	0	50	90		0	0	90	40	0	50	0	0	80	10	60	0	70	0	0	0	10	10	0
4	33	Elucidation of the neural mechanisms of sleep and dreams.	1	118	3	19	78	48	16	48	36	1	8	2	69	62	14	6	9	65	30	2	29	0	25	69	19	25	5	49	0	0	1	12	19	2
			2	99	1	22	77	48	12	57	30	1	7	0	72	66		5	5	78	28	1	30	0	17	84	14	21	3	56	0	0	1	12	25	0
			X	1	100	0	0	50	0	100	0	0	0	0	100	0		0	0	100	0	0	0	0	0	100	0	0	0	100	0	0	0	100	0	0
14	93	Elucidation of molecular mechanism of memory.	1	68	15	25	60	66	39	47	13	2	32	4	71	74	15	9	15	78	47	3	43	0	13	69	40	32	15	60	0	1	1	13	41	
			2	58	14	21	66	65	36	52	10	2	33	2	72	67		7	16	86	40	0	41	0	9	74	34	29	7	64	0	0	0	17	48	
			X	8	100	0	0	81	63	38	0	0	38	0	88	63		13	0	100	63	0	50	0	0	100	38	38	0	50	0	0	0	25	25	
4	36	Elucidation of the neurobiological basis for emotion.	1	118	8	25	67	56	22	59	18	1	8	2	66	62	16	2	14	71	36	4	27	0	22	71	19	29	8	54	2	0	0	17	26	2
			2	102	5	25	70	57	20	69	11	1	6	0	71	68		4	9	76	36	3	24	0	19	80	19	25	2	57	1	0	1	14	30	2
			X	5	100	0	0	70	40	60	0	0	20	0	100	60		0	0	80	40	0	40	0	20	100	60	0	20	100	0	0	0	20	60	0
3	35	Elucidation of human creative mechanism to such an extent that allows to apply to computer science.	1	144	14	35	51	69	47	37	15	1	43	3	17	84	17	19	14	69	33	5	31	1	20	65	42	16	10	46	1	1	1	6	33	1
			2	123	8	29	63	71	50	35	15	0	47	1	9	89		21	9	72	28	3	30	0	18	72	37	9	5	60	2	2	1	4	40	0
			X	10	100	0	0	90	80	20	0	0	60	0	10	100		10	0	90	40	10	90	0	0	100	50	0	0	80	0	0	10	0	70	0
4	65	Elucidation of brain mechanisms for logical reasoning.	1	138	7	26	67	67	40	47	11	1	17	1	43	81	18	9	14	78	38	1	36	0	14	68	28	33	4	59	1	0	1	7	21	1
			2	113	4	25	72	67	36	59	5	0	15	0	40	88		9	8	87	37	1	35	0	9	74	24	25	1	61	0	0	0	4	24	0
			X	4	100	0	0	88	75	25	0	0	50	0	25	100		0	0	100	25	0	50	0	0	75	50	75	0	75	0	0	0	25	25	0

Domain	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%)			Importance (index, %)					Expected effect (%)			
					High	Medium	Low	Index	High	Medium	Low	Unnecessary	Socio-economic development	Resolution of global problems	People's needs	Expansion of intellectual resources

Forecasted realization time							Leading countries (%)						Measures the government should adopt (%)							Potential problems (%)			
2001	2008	2011	2014	2021	2025	Will not be realized (%)	Do not know (%)	USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop research base	Increase government research funding	Adjust regulations (relax taxpayers)	Others	Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects

1.4 Entstehung von Leben

4	19	Elucidation of the molecular mechanism of life creation.	1	231	9	31	60	52	27	35	29	8	7	11	16	89				21	18	71	36	6	21	0	19	59	14	21	14	49	3	1	7	4	35	2
			2	194	7	27	66	50	21	42	32	5	4	1	9	93	19			21	17	80	40	6	19	0	14	70	9	19	7	56	3	1	2	3	45	1
			X	13	100	0	0	65	46	31	15	8	8	8	23	100				23	0	85	54	23	31	0	0	69	15	23	8	46	8	8	8	0	46	0

1.5 Evolution und Phylogenese

4	94	Advancement of the analysis of the human genome diversity regarding individual races, and the elucidation of the origin and phylogeny of human being.	1	235	10	26	64	44	13	42	37	8	3	6	22	87				2	11	80	49	1	32	0	11	55	14	17	43	47	2	2	1	18	49	2
			2	196	11	23	66	45	11	49	37	3	1	4	15	95	20			2	8	84	48	1	28	0	10	71	9	10	45	54	2	2	1	13	55	0
			X	22	100	0	0	60	32	50	14	5	0	5	18	95				0	0	100	68	0	36	0	0	82	14	18	41	64	0	0	0	14	59	0
4	93	Emergence of experimental evidence of the evolutionary mechanism of organisms.	1	216	12	29	59	48	18	43	35	4	5	14	10	92				13	16	66	40	3	26	0	20	64	16	24	21	53	0	0	7	2	27	4
			2	177	10	25	64	47	14	49	34	2	4	5	7	95	21			11	15	75	45	3	20	0	15	77	9	19	18	58	1	0	5	1	32	1
			X	18	100	0	0	78	61	28	11	0	11	11	17	100				11	11	94	61	0	39	0	6	78	11	33	22	61	0	0	0	0	33	0

1.6 Ontogenese

4	84	Complete elucidation of the molecular mechanisms of development and differentiation.	1	242	23	32	45	71	48	40	11	0	15	13	48	81				5	14	86	56	1	40	0	6	73	22	26	22	66	1	0	5	6	21	3
			2	201	21	31	47	71	48	44	8	1	10	7	46	81	22			7	8	92	60	0	41	0	3	82	16	21	12	68	1	0	3	4	25	1
			X	43	100	0	0	82	67	28	2	2	14	12	47	91				7	5	98	81	0	65	0	0	93	23	26	19	70	0	0	2	2	23	5

2 Hybride Systeme

2.1 Hybride Hardware

2.1.1 Allgemeine Thesen zu Biocomputern

2.1.2 Hybride Hardware auf molekularer Ebene

2.1.3 Hybride Hardware auf zellulärer Ebene

2.1.3.1 Chip/Zell-Interface

2.1.3.2 Künstliche Nervensysteme

2.1.4 Hybride Hardware auf Organ-/Organismus-Ebene

2.2 Biomolekulare Speicher

2.3 Biosensorik

2.4 Implantate/künstliche Organe

2.4.1 Mikromaschinen

2.4.2 Künstliche Bewegung von Gliedmaßen/Muskeln

2.4.3 Künstliche innere Organe

2.4.3.1 Allgemeine Thesen zur Verbreitung von Implantaten

2.4.3.2 Cochlea

2.4.3.3 Cornea

2.4.3.4 Endokrine Organe

2.4.3.5 Blase

2.4.3.6 Lunge

2.4.3.7 Herz

2.4.3.8 Niere

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%)			Importance (index, %)					Expected effect (%)			
					High	Medium	Low	Index	High	Medium	Low	Unnecessary	Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources

Forecasted realization time								Leading countries (%)						Measures the government should adopt (%)								Potential problems (%)			
2001	2006	2011	2016	2021	2026	Will not be realized (%)	Do not know (%)	USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/tighten)	Others	Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects

2.1.1 Allgemeine Thesen zu Biocomputern

3	1	Practical use of bio-computers based on a new algorithm which takes into account the organic information processing system.	1	171	6	30	63	62	36	43	19	2	54	13	22	69	8	8	77	12	2	25	0	19	61	49	20	21	42	2	1	5	4	27	2
			2	141	4	27	69	60	29	57	12	2	54	9	16	76	7	9	75	8	1	21	0	22	65	45	18	16	47	2	1	4	6	34	1
			X	6	100	0	0	83	67	33	0	0	100	33	33	67	0	17	100	0	0	67	0	0	100	67	17	0	67	0	0	0	0	17	0
4	10	Systematization of the basic concepts of bio-computer architecture.	1	148	11	27	62	65	41	42	12	4	71	11	17	53	7	9	77	22	1	28	0	14	57	55	24	7	41	1	1	4	4	14	2
			2	121	10	20	70	61	36	51	11	2	78	6	15	44	5	6	85	23	2	29	0	11	64	62	20	3	48	1	2	2	4	20	1
			X	12	100	0	0	67	12	50	0	8	75	8	0	58	0	0	92	0	0	33	0	0	67	58	25	0	42	0	8	0	0	0	0

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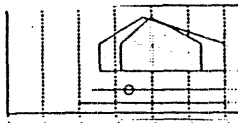

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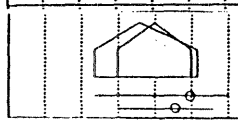
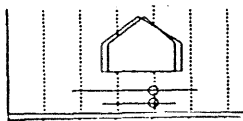


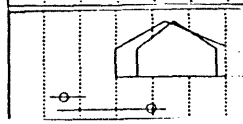
2.1.2 Hybride Hardware auf molekularer Ebene

4	9	Development of biodevices (protein transistors, for example) that can be used in electronics.	1	172	13	22	65	62	36	43	19	2	74	17	23	31	8	9	72	25	0	37	1	16	52	52	22	5	44	1	1	9	6	12	4
			2	132	11	22	67	61	35	50	11	1	80	11	27	26	6	4	86	22	1	46	0	8	62	61	14	2	55	0	2	5	5	14	2
			X	11	100	0	0	75	50	50	0	0	61	29	21	43	14	0	79	7	0	50	0	0	57	79	7	0	43	0	7	7	0	14	0
4	61	Development of materials similar to organisms, which have self-recognizing and judging functions.	1	104	5	21	74	60	31	47	20	2	61	5	55	27	10	11	62	23	1	30	0	23	54	51	26	2	46	1	0	6	6	19	2
			2	80	3	23	75	55	19	65	15	1	70	1	65	18	11	8	69	19	1	25	0	25	60	53	15	0	46	1	0	4	4	23	1
			X	2	100	0	0	50	0	100	0	0	100	0	100	0	0	0	100	0	0	100	0	0	100	50	0	0	100	0	0	0	0	0	0

25



26



Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (*-) High	Medium	Low	Importance (index, *-) Index	High	Medium	Low	Unnecessary	Expected effect (*-) Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources

Forecasted realization time (2001, 2008, 2011, 2014, 2021, 2025)	Will not be realized (*-)	Do not know (*-)	Leading countries (*-) USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Measures the government should adopt (*-) Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax toughness)	Others	Potential problems (*-) Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects

2.1.3 Hybride Hardware auf zellulärer Ebene

2.1.3.1 Chip/Zell-Interface

2	65	Development of sensors that could be substituted for human sensation, capable of directly stimulating nerves.	1	59	8	20	71	54	26	40	30	4	44	3	83	17	27	3	14	66	25	3	32	0	24	49	41	20	7	36	3	0	3	22	27	0
			2	61	5	13	82	55	23	52	25	0	39	3	82	10		3	10	75	21	3	39	0	16	62	48	11	3	43	5	0	2	33	43	0
			X	3	100	0	0	100	100	0	0	0	67	0	100	0		0	0	67	33	0	67	0	0	67	33	0	0	33	0	0	0	0	0	0
4	56	Establishment of interface technology between neural information and artificial organism structures.	1	101	10	26	64	65	39	46	11	3	49	1	77	29	28	7	10	70	23	0	31	0	18	55	53	30	2	48	2	1	0	12	23	1
			2	91	9	18	74	61	30	58	10	2	47	1	78	23		5	5	84	20	0	37	0	12	64	51	24	1	54	1	0	0	11	26	1
			X	8	100	0	0	81	63	38	0	0	75	0	88	50		0	0	100	50	0	88	0	0	63	63	38	0	75	0	0	0	0	0	0

2.1.3.2 Künstliche Nervensysteme

2	59	Elucidation of the interconnective mechanism in the cerebral nervous system, and development of artificially functioning bio-nerve circuits with about 10,000 cells	1	127	9	18	73	67	39	51	10	0	65	2	39	62	29	13	11	80	35	6	46	0	16	66	40	24	11	47	2	1	2	6	24	2
			2	123	5	18	77	64	33	59	8	0	64	0	31	66		11	7	88	30	2	46	0	8	73	41	15	6	59	0	1	1	3	28	2
			X	6	100	0	0	92	83	17	0	0	100	0	17	50		17	0	83	33	0	100	0	0	100	33	17	0	67	0	0	0	0	17	0
94		Development of hybrid-type artificial intelligence that combines ICs and living cells.	1	46	15	15	70	57	24	56	20	0	52	4	65	50	30	20	20	72	17	4	30	0	22	57	54	24	11	48	0	0	2	22	52	0
			2	42	14	17	69	55	21	55	24	0	55	2	74	43		14	19	83	19	2	36	0	12	69	62	24	0	52	0	0	0	24	57	0
			X	6	100	0	0	54	17	67	17	0	50	0	83	17		17	0	100	33	0	33	0	0	83	33	50	0	33	0	0	0	33	33	0

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%)			Importance (index, %)					Expected effect (%)			
					High	Medium	Low	Index	High	Medium	Low	Unnecessary	Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources

Forecasted realization time (2001, 2006, 2011, 2016, 2021, 2026)		Will not be realized (%)	Do not know (%)	Leading countries (%)						Measures the government should adopt (%)							Potential problems (%)			
				USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax toughen)	Others	Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects

2.1.4 Hybride Hardware auf Organ-/Organismus-Ebene

83	Development of a device to sense the needs of demented aged people.	1	61	15	23	62	64	41	37	20	2	36	2	92	28	31	16	15	46	31	0	25	0	34	64	48	33	10	54	3	3	0	16	36	8
		2	56	13	20	68	67	44	35	19	2	34	0	89	18		14	9	54	25	0	27	0	30	68	45	23	2	52	4	4	0	14	38	4
		X	7	100	0	0	54	33	33	17	17	29	0	86	29		14	0	71	57	0	29	0	0	71	43	43	0	14	0	0	0	14	14	14
14	58 Development of interfaces enabling direct linkage between the computer and the brain.	1	102	8	26	66	68	43	44	9	3	58	1	57	38	32	22	10	70	24	0	30	0	13	54	49	32	0	41	2	0	2	15	36	1
		2	93	6	19	74	63	37	52	10	2	69	0	57	34		17	6	81	22	0	28	1	13	61	48	26	0	47	2	0	1	13	41	0
		X	6	100	0	0	83	67	33	0	0	50	0	50	67		17	0	100	50	0	83	0	0	83	67	33	0	50	0	0	0	0	33	0
2	21 Development of an "artificial intelligence chip" capable of understanding and sharing human emotions.	1	170	8	18	74	66	42	42	14	2	67	3	72	37	33	21	15	71	20	2	36	0	20	60	41	20	9	39	1	3	0	15	42	1
		2	162	6	15	79	64	34	54	10	1	59	0	75	36		22	10	80	15	1	36	0	16	70	43	11	6	41	1	1	0	10	50	1
		X	10	100	0	0	89	78	22	0	0	80	0	80	30		10	0	100	40	0	50	0	0	90	70	30	10	50	0	0	0	10	40	0
3	38 Become possible for computers, using electromagnetic data, to read the information recorded inside the human brain.	1	113	7	21	72	55	31	36	24	9	37	3	42	67	34	35	14	50	20	4	25	0	29	44	22	13	14	33	8	1	1	42	58	0
		2	92	5	15	79	55	26	46	21	7	33	1	39	75		39	5	60	17	2	22	0	23	59	22	9	11	37	7	2	0	41	67	0
		X	5	100	0	0	70	40	60	0	0	60	0	60	80		40	20	100	40	0	60	0	0	80	40	40	0	60	20	0	0	80	80	0

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%)			Importance (index, %)					Expected effect (%)			
					High	Medium	Low	Index	High	Medium	Low	Unnecessary	Socio-economic development	Resolution of global problems	People's needs	Expansion of intellectual resources

Forecasted realization time								Leading countries (%)						Measures the government should adopt (%)							Potential problems (%)			
2001	2006	2011	2016	2021	2026	Will not be realized (%)	Do not know (%)	USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/tighten)	Others	Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects

2.2 Biomolekulare Speicher

74	Practical use of biochip devices that have a memory density (10^{12} bit/cm^2) 1,000 times that of current semiconductor devices (10^9 bits/cm^2).	1	67	6	15	79	75	55	34	9	2	84	21	37	33			7	21	57	13	0	46	1	19	49	30	24	9	57	0	3	6	6	12	4
		2	59	5	10	85	82	68	23	9	0	88	12	29	27			8	14	68	2	0	63	3	14	61	25	14	5	58	0	2	5	5	12	5
		X	3	100	0	0	100	100	0	0	0	67	33	33	33			0	0	67	0	0	100	33	0	100	33	0	33	100	0	0	0	0	0	0

2.3 Biosensorik

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%)			Importance (index, %)					Expected effect (%)				Forecasted realization time (2001, 2006, 2011, 2016, 2021, 2026)		Leading countries (%)					Measures the government should adopt (%)							Potential problems (%)			
					High	Medium	Low	Index	High	Medium	Low	Unnecessary	Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources	Will not be realized (%)	Do not know (%)	USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
2	62	Practical use of biosensors utilizing antibodies.	1	67	12	24	64	68	42	48	9	2	42	6	78	16	36	0	3	75	34	3	52	0	12	49	34	16	25	31	4	0	9	18	4	0
			2	63	8	24	68	65	33	60	6	0	43	6	92	3		0	0	81	35	2	63	0	8	60	43	8	22	33	2	0	8	27	3	0
			X	5	100	0	0	80	60	40	0	0	60	0	80	0		0	0	60	60	0	60	0	0	60	40	0	0	20	0	0	0	0	0	0
2	55	Practical use of ultra-small bio-sensors for use in medical and other applications, based on the utilization of biochemical reactions.	1	113	7	24	69	68	40	51	9	0	56	2	84	10	37	0	6	75	37	4	60	0	15	56	51	19	14	43	9	0	2	10	8	1
			2	105	9	16	75	68	38	60	3	0	52	2	89	4		0	2	87	31	2	73	0	6	67	55	8	10	50	5	0	0	12	6	1
			X	9	100	0	0	78	56	44	0	0	56	0	67	0		0	11	78	22	0	89	0	0	89	56	0	0	44	11	0	0	22	0	0
3	31	Development of multipurpose assessment methods for taste, smell, etc., which do not depend upon the physical senses of humans.	1	84	4	23	74	48	15	50	34	1	48	6	56	27	38	7	15	31	19	2	29	0	43	42	31	10	15	29	6	2	4	1	20	2
			2	73	3	16	81	45	11	46	41	1	42	4	64	19		8	7	32	15	1	37	0	36	45	33	3	10	22	3	3	1	5	29	3
			X	2	100	0	0	75	50	50	0	0	50	0	50	50		0	0	50	50	0	50	0	50	50	50	0	0	100	0	0	50	0	50	50
2	58	Practical use of biosensors capable of identifying single molecule.	1	96	9	19	72	58	28	49	23	0	60	8	50	32	39	7	16	65	33	3	34	0	20	57	36	22	9	41	1	0	2	1	2	2
			2	94	6	17	77	56	20	62	18	0	61	3	53	36		3	13	76	32	1	45	0	14	69	40	11	7	43	1	0	0	0	2	2
			X	6	100	0	0	75	50	50	0	0	83	0	33	17		0	17	50	0	0	50	0	17	83	17	0	0	50	0	0	0	0	0	0

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (*a)			Importance (index, *a)					Expected effect (*a)			
					High	Medium	Low	Index	High	Medium	Low	Unnecessary	Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources

Forecasted realization time							Leading countries (*a)						Measures the government should adopt (*a)							Potential problems (*a)			
2001	2006	2011	2016	2021	2026	Will not be realized (*a)	Do not know (*a)	USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax toughen)	Others	Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects

2.4 Implantate/künstliche Organe

2.4.1 Mikromaschinen

2	53	Practical use of devices which integrate sensors, controllers, and actuators, using micromachine technology	1	208	9	27	64	68	42	47	10	0	78	10	62	10	40		2	5	78	31	2	70	0	8	49	58	33	2	46	2	0	1	5	7	1
			2	194	8	25	66	68	40	53	7	0	80	6	63	5			2	3	82	27	1	76	0	5	51	59	27	0	53	1	0	0	3	5	1
			X	16	100	0	0	91	81	19	0	0	94	13	75	0			0	0	88	56	0	88	0	0	44	63	25	0	63	0	0	0	0	6	0
4	62	Development of diagnostic and medical treatment micromachines capable of traveling on their own inside organisms (body cavity organs)	1	114	8	22	70	71	46	47	5	1	51	0	90	17	41		6	11	66	24	1	54	0	21	54	65	29	2	47	2	1	3	17	14	4
			2	91	5	23	71	69	40	55	4	0	47	0	96	9			3	3	77	19	0	51	0	18	66	75	19	0	51	2	2	1	20	14	0
			X	5	100	0	0	90	80	20	0	0	60	0	100	20			0	0	100	40	0	100	0	0	60	80	60	0	60	0	20	0	0	0	0
4	31	Development of technologies, such as biomotors, using the biological energy conversion mechanisms.	1	165	12	32	56	60	31	48	21	1	68	41	25	28	42		5	11	75	27	1	50	0	13	54	49	28	1	51	2	2	11	5	6	3
			2	137	10	31	58	59	27	56	15	1	76	31	23	25			3	5	80	23	1	52	0	9	64	53	23	1	54	1	2	12	6	5	2
			X	14	100	0	0	79	57	43	0	0	86	29	21	36			0	0	79	21	0	57	0	14	50	43	36	7	64	0	7	21	14	7	0
2	52	Development of medical micromachine devices powered by the ATP etc. contained in blood.	1	85	7	18	75	69	47	37	14	2	51	5	85	31	43		14	15	61	22	0	36	0	21	53	40	19	7	44	6	1	4	9	20	2
			2	85	5	18	78	69	46	38	15	1	47	2	84	26			15	14	73	24	0	44	0	16	64	41	14	2	54	4	1	1	6	24	1
			X	4	100	0	0	63	50	0	50	0	75	0	75	0			25	0	50	25	0	100	0	0	100	50	0	0	75	0	0	0	0	50	0
14	60	Practical use of batteries of artificial organs implanted in the living body.	1	55	5	35	60	55	24	51	22	4	44	13	87	22	44		5	13	69	18	0	44	0	20	62	62	25	7	49	4	2	5	18	24	
			2	41	7	27	66	54	20	60	18	3	44	5	88	12			7	5	85	15	0	51	0	10	80	56	24	2	46	2	0	2	17	32	
			X	3	100	0	0	75	50	50	0	0	67	0	100	0			33	0	100	0	0	67	0	0	33	33	33	0	0	0	0	0	0	0	

2.4.2 Künstliche Bewegung von Gliedmaßen/Muskeln

85	Development of controlling devices which help the cooperative muscular actions enabling object-oriented movement.	1	55	13	22	65	56	24	54	20	2	40	0	96	24	45		5	9	58	33	0	36	2	27	64	51	24	7	58	2	2	2	24	16
		2	45	9	20	71	55	23	53	21	2	42	0	93	18			4	9	73	29	0	47	0	13	69	47	22	0	64	0	0	0	27	20
		X	4	100	0	0	50	0	100	0	0	75	0	100	0			0	0	50	75	0	75	0	0	75	50	50	0	50	0	0	0	0	0
86	Widespread use of artificial legs featuring a small power source and computer control.	1	54	17	24	59	53	17	62	19	2	41	0	98	7	46		0	6	61	35	2	57	0	20	61	67	22	6	56	6	2	2	24	20
		2	48	10	19	71	51	15	62	21	2	35	0	96	8			2	4	79	33	0	67	0	6	71	60	17	2	44	2	0	0	23	19
		X	5	100	0	0	88	75	25	0	0	40	0	100	0			0	0	80	60	0	80	0	0	80	100	40	0	40	0	0	0	0	0

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%)			Importance (index, %)					Expected effect (%)			
					High	Medium	Low	Index	High	Medium	Low	Unnecessary	Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources

Forecasted realization time							Leading countries (%)						Measures the government should adopt (%)							Potential problems (%)			
2001	2006	2011	2016	2021	2026	Will not be realized (%)	Do not know (%)	USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax toughen)	Others	Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects

2.4.3 Künstliche innere Organe

2.4.3.1 Allgemeine Thesen zur Verbreitung von Implantaten

4	51	Practical use of artificial organs (pancreases, kidneys, livers, etc.) incorporating human cells and tissues.	1	177	9	32	59	75	53	43	4	1	37	0	98	9	47	2	8	80	33	2	37	0	11	56	58	25	3	54	16	0	1	17	42	2
			2	147	10	29	62	78	58	40	3	0	35	1	98	1		1	4	87	28	1	38	0	7	61	63	20	2	62	15	0	1	16	47	0
			X	14	100	0	0	88	77	23	0	0	50	0	93	7		7	7	100	43	7	71	0	0	50	71	14	0	57	21	0	0	14	36	0
1	2	Practical use of hybrid artificial organs in which cells are immobilized on materials such as high polymer plastics.	1	140	4	16	80	66	39	50	10	1	24	3	96	7	48	3	7	71	18	0	39	0	21	53	50	15	13	41	13	0	4	19	48	3
			2	118	3	14	83	64	33	55	12	0	19	3	97	2		0	8	78	9	0	41	0	15	66	51	8	10	47	7	0	3	19	67	2
			X	4	100	0	0	69	50	25	25	0	25	0	100	0		0	0	100	25	0	75	0	0	50	75	25	0	50	0	0	0	0	50	0

2.4.3.2 Cochlea

30	Practical use of implanted artificial cochleas effective for both conductive hearing loss and perceptive hearing loss.	1	40	15	18	68	61	28	59	13	0	53	0	95	25	49	13	10	63	38	0	35	3	23	65	55	20	10	55	3	0	3	18	33
		2	37	11	14	76	60	27	59	14	0	49	0	89	16		3	8	78	38	0	35	3	16	68	59	16	3	51	3	0	0	16	38
		X	4	100	0	0	75	50	50	0	0	75	0	100	25		0	0	100	75	0	50	0	0	75	75	25	0	50	0	0	0	0	0

2.4.3.3 Cornea

4	53	Development of an artificial cornea, allowing the visually impaired to regain their sight.	1	112	5	21	73	68	45	42	12	2	22	0	96	9	50	19	12	56	19	1	13	0	27	54	46	24	1	45	4	0	0	11	21	3
			2	95	4	22	74	74	52	41	6	1	22	0	100	3		16	7	69	15	1	18	0	26	67	53	21	0	58	2	1	0	15	23	1
			X	4	100	0	0	56	25	50	25	0	25	0	100	0		0	0	100	25	0	50	0	0	75	25	25	0	50	0	0	0	0	0	0
	31	Development of artificial eyes featuring electronic circuitry that can be connected to nerve and brain cells.	1	46	15	28	57	50	18	49	31	2	33	2	96	33	51	22	22	59	17	9	20	0	24	63	52	24	13	59	2	2	4	22	20
			2	44	11	23	66	49	14	58	26	2	36	0	93	32		18	16	80	16	5	25	0	14	73	41	23	5	55	0	0	0	25	30
			X	5	100	0	0	38	0	50	50	0	40	0	100	60		20	0	80	20	20	40	0	20	80	40	80	0	60	0	0	0	40	20

2.4.3.4 Endokrine Organe

	68	Development of hybrid-type artificial endocrine organs in which living cells and artificial objects coexist.	1	52	8	29	63	53	21	52	23	4	40	0	90	25	52	4	27	56	17	0	33	0	33	62	67	25	6	52	0	0	2	17	29
			2	45	9	27	64	57	22	60	18	0	49	0	93	18		7	11	71	9	0	36	0	20	64	64	22	2	58	0	0	0	16	40
			X	4	100	0	0	56	25	50	25	0	75	0	100	25		0	25	75	25	0	75	0	0	75	100	0	0	75	0	0	0	50	50
	66	Practical use of fully implanted artificial pancreas.	1	60	10	13	77	60	31	49	19	2	40	2	90	22	53	13	13	65	20	0	33	0	25	60	58	27	10	50	0	0	3	15	27
			2	46	15	17	67	66	37	52	11	0	43	2	93	13		11	15	78	15	0	37	0	15	67	57	22	2	52	2	0	2	15	35
			X	7	100	0	0	71	57	14	29	0	57	14	86	14		14	14	86	29	0	57	0	14	71	57	29	0	43	0	0	14	29	43
	67	Development of artificial liver (external devices supporting liver functions) usable on a long-term, continuous basis.	1	59	7	17	76	62	32	54	13	2	42	2	92	24	54	5	12	66	24	0	36	0	22	64	66	24	10	56	3	0	2	15	24
			2	44	9	23	68	61	26	67	7	0	48	0	93	18		2	9	77	20	0	41	0	16	61	64	16	7	55	2	0	0	14	39
			X	4	100	0	0	75	50	50	0	0	75	0	100	0		0	0	100	0	0	100	0	0	100	75	25	0	75	0	0	0	25	50

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%)			Importance (index, %)					Expected effect (%)			
					High	Medium	Low	Index	High	Medium	Low	Unnecessary	Socio-economic development	Resolution of global problems	People's needs	Expansion of intellectual resources

Forecasted realization time			Leading countries (%)					Measures the government should adopt (%)							Potential problems (%)			
2001 2006 2011 2016 2021 2025	Will not be realized (%)	Do not know (%)	USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax toughen)	Others	Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects

2.4.3.5 Blase

72	Practical use of implanted bladder control devices.	1	47	19	28	53	53	20	54	26	0	32	0	96	9	55		2	9	57	17	0	26	0	34	66	57	30	9	60	0	2	2	19	26
		2	43	12	23	65	54	21	53	26	0	37	0	95	9			0	5	72	21	0	37	0	19	74	58	19	2	49	5	2	0	26	33
		X	5	100	0	0	65	40	40	20	0	40	0	100	0			0	0	60	20	0	20	0	20	60	100	40	0	40	0	0	0	0	20

2.4.3.6 Lunge

64	Practical use of fully implanted artificial lungs.	1	63	11	27	62	56	24	53	19	3	38	2	97	19	56		11	10	71	24	5	25	0	21	56	65	29	6	52	3	0	3	17	29
		2	51	10	20	71	61	26	64	10	0	37	2	96	14			12	10	80	12	0	25	0	14	61	65	22	2	55	2	0	2	18	33
		X	5	100	0	0	60	20	80	0	0	60	0	80	20			0	0	80	40	0	0	0	20	80	60	40	0	40	0	0	0	0	20

2.4.3.7 Herz

63	Development of fully implanted artificial hearts.	1	73	11	22	67	63	34	49	15	1	45	0	97	22	57		5	4	82	25	1	55	0	11	58	63	36	5	49	3	0	1	19	38
		2	56	9	20	71	65	34	57	9	0	48	2	95	13			2	4	91	20	0	61	0	4	57	59	32	0	52	2	0	0	14	45
		X	5	100	0	0	80	60	40	0	0	80	0	100	20			0	0	100	0	0	100	0	0	60	80	40	0	60	20	0	0	40	40

2.4.3.8 Niere

52	Development of an entirely implantable artificial kidney.	1	144	10	27	63	79	60	34	5	1	26	0	95	8	58		3	8	70	30	1	37	0	17	53	65	26	2	49	9	1	0	13	26	3
		2	119	8	22	70	83	67	30	3	0	20	1	98	5			4	4	84	28	0	38	0	10	61	72	21	0	57	3	2	0	14	29	1
		X	10	100	0	0	90	80	20	0	0	30	0	100	0			10	0	90	30	0	60	0	0	40	100	30	0	60	0	0	0	0	20	0
65	Practical use of fully implanted artificial kidneys.	1	59	15	14	71	63	34	52	12	2	44	3	93	22	59		12	7	73	25	0	34	0	24	59	61	32	3	49	3	0	3	15	29
		2	47	17	11	72	63	30	62	9	0	45	2	98	15			13	4	81	17	0	36	0	13	68	64	21	0	53	4	0	2	17	36
		X	8	100	0	0	78	63	25	13	0	63	13	88	25			0	0	88	25	0	75	0	0	100	75	25	0	38	0	0	13	50	50

3 Bioanaloge Basistechnologien

3.1 Bioanaloge Hardware

3.1.1 Allgemeine Thesen zu Selbstorganisations-/Regenerations-/Reproduktionsfähigkeit

3.1.2 Analogie zu zellulären Prozessen

3.1.3 Neural-Computers

3.1.4 Automatisches Chipdesign

3.2 Anpassungsfähige Software

3.3 Künstliche Intelligenz

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%)			Importance (index, %)					Expected effect (%)			
					High	Medium	Low	Index	High	Medium	Low	Unnecessary	Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources

Forecasted realization time (2001, 2006, 2011, 2016, 2021, 2026)			Leading countries (%)						Measures the government should adopt (%)							Potential problems (%)			
	Will not be realized (%)	Do not know (%)	USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax toughen)	Others	Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects

3.1 Bioanaloge Hardware

3.1.1 Allgemeine Thesen zu Selbstorganisations-/Regenerations-/Reproduktionsfähigkeit

10	1	Discovery of a number of new laws, effects and phenomena through microtechniques, leading to a radical change in the theories of designing artificial objects.	1	115	15	34	51	73	52	35	13	0	67	21	33	59	60	2	11	77	24	1	58	2	15	53	49	35	5	50	3	2	14	13	12	1
			2	90	12	29	59	73	52	38	10	0	69	13	36	62		0	4	78	17	0	54	1	13	59	50	34	1	49	1	0	12	13	13	0
			X	11	100	0	0	91	82	18	0	0	73	36	45	73		0	0	82	45	0	73	9	0	73	64	36	0	55	0	0	9	9	9	0
10	52	Discovery of new laws, effects and phenomena based on the functions of living organisms, leading to a radical change in the theories of designing artificial objects.	1	82	7	27	66	68	44	42	14	0	62	26	18	78	61	0	22	54	24	4	29	0	29	62	37	15	10	48	5	0	10	6	16	1
			2	67	7	25	67	65	38	47	15	0	66	18	15	79		0	18	58	18	1	30	0	30	75	31	10	4	46	1	1	6	7	16	0
			X	5	100	0	0	90	80	20	0	0	80	40	40	60		0	0	0	20	0	20	0	20	20	20	0	0	40	0	0	0	0	0	0
10	60	Development of new evolving structure systems and self-multiplicating and repairing devices via elucidation of biological mechanisms (e.g. homeostatics and homeodynamics including autosynthetic control and in vivo nuclear reaction (reaction by which elements are formed in a living organism)).	1	57	12	25	63	63	33	50	17	0	74	14	25	53	62	7	12	60	16	2	37	0	32	70	32	11	12	60	2	2	7	11	12	2
			2	47	6	23	70	62	26	70	4	0	83	9	19	45		2	15	68	11	0	30	0	28	79	28	4	2	64	2	0	9	17	17	0
			X	3	100	0	0	67	33	67	0	0	67	0	0	67		0	0	67	67	0	67	0	33	67	33	0	0	100	0	0	0	0	33	0
4	14	Development of biomimetic elements which duplicate themselves according to information.	1	146	8	34	59	54	24	48	22	5	58	25	21	13	63	14	12	63	16	1	20	0	26	55	45	20	10	38	3	0	18	5	14	1
			2	119	8	27	65	51	17	54	26	3	65	18	17	37		13	10	70	13	1	18	0	24	64	42	18	8	40	3	0	20	5	15	0
			X	10	100	0	0	78	60	30	10	0	60	30	20	80		10	0	100	30	10	50	0	0	60	30	30	10	70	0	0	20	0	10	0
4	59	Development of devices with self-assembling, self-organizing, and self-recovering capabilities.	1	93	10	27	63	62	34	49	11	6	65	3	41	34	64	11	18	67	22	0	26	0	26	55	52	34	2	43	1	0	2	4	15	2
			2	80	6	24	70	61	27	66	6	1	75	0	38	30		10	10	75	18	0	25	0	21	61	56	29	1	44	0	0	1	5	20	0
			X	5	100	0	0	80	60	10	0	0	60	0	20	10		0	20	100	20	0	80	0	0	40	100	40	0	40	0	0	0	0	0	0

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%)			Importance (index, %)					Expected effect (%)			
					High	Medium	Low	Index	High	Medium	Low	Unnecessary	Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources

Forecasted realization time (2001, 2006, 2011, 2016, 2021, 2025)			Leading countries (%)						Measures the government should adopt (%)							Potential problems (%)			
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3.1.2 Analogie zu zellulären Prozessen

2	4	Elucidation of the mechanisms by which single-cell organisms etc. respond to external stimuli, and realization of such mechanisms artificially	1	103	5	14	82	61	30	55	15	0	40	11	42	68	65	2	10	70	34	3	41	0	18	52	43	38	29	43	5	0	18	5	33	0
			2	108	3	11	86	61	29	58	13	0	31	8	37	75		2	9	76	31	1	39	0	14	63	39	34	24	43	5	0	15	5	38	0
			X	3	100	0	0	100	100	0	0	0	33	33	67	67		0	0	100	67	0	100	0	0	100	67	33	33	33	0	0	0	0	33	0

3.1.3 Neural-Computers

4	57	Development of neural-computers with new logic structures modeled on brain functions.	1	118	6	25	69	73	50	44	4	2	74	2	38	53	66	4	8	86	30	1	42	0	6	65	55	31	2	52	1	0	2	8	27	1
			2	104	3	19	78	74	50	46	3	1	85	0	33	49		3	6	90	26	1	42	0	2	69	57	24	0	55	0	0	1	8	31	1
			X	3	100	0	0	100	100	0	0	0	67	0	0	100		33	0	100	33	0	100	0	0	100	100	33	0	33	0	0	0	0	33	0
2	15	Practical use of semiconductor neural network chips on the order of one million neurons.	1	176	9	24	67	63	35	51	13	2	85	6	26	35	67	10	14	76	20	1	59	0	10	55	50	19	1	48	2	1	1	2	11	1
			2	174	7	25	68	64	33	59	9	0	90	5	21	33		7	7	86	19	0	64	0	7	68	56	14	0	53	1	0	1	2	6	1
			X	13	100	0	0	79	62	31	8	0	92	15	23	46		8	0	92	31	0	69	0	0	69	54	15	0	85	0	0	0	8	8	8
4	60	Development of electric circuits with similar self-organization and self-restoration functions as neural networks.	1	83	7	27	66	66	41	42	15	1	69	0	37	36	68	8	11	71	19	2	35	0	17	55	55	34	1	37	2	0	1	6	14	1
			2	75	4	28	68	63	31	58	11	0	81	0	35	37		5	8	79	17	3	35	0	15	65	55	24	0	39	1	0	1	5	19	0
			X	3	100	0	0	83	67	33	0	0	67	0	0	100		0	33	100	33	0	100	0	0	100	100	0	0	67	0	0	0	0	0	0

3.1.4 Automatisches Chipdesign

2	27	Practical use of virtual factory technology, in which high-performance LSI with several hundred K gates or more can be designed automatically by giving the required specifications on the system level.	1	179	13	30	57	72	49	42	8	1	89	6	9	11	69	3	4	85	13	0	42	1	8	65	45	21	1	36	1	2	3	1	4	2
			2	172	10	27	63	76	55	40	4	1	95	2	6	6		2	4	88	7	0	50	1	5	66	48	18	1	41	0	1	1	1	2	2
			X	18	100	0	0	97	94	6	0	0	100	6	11	0		6	0	89	17	0	67	0	0	72	61	17	0	56	0	6	0	0	6	6

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%)			Importance (index, %)					Expected effect (%)			
					High	Medium	Low	Index	High	Medium	Low	Unnecessary	Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources

Forecasted realization time								Leading countries (%)						Measures the government should adopt (%)							Potential problems (%)			
2001	2006	2011	2016	2021	2026	Will not be realized (%)	Do not know (%)	USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax loosen)	Others	Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects

3.2 Anpassungsfähige Software

3	24	Development of software capable of using sensory and learning functions to rewrite itself into an even more advanced program.	1	187	23	43	34	64	35	51	14	0	65	5	21	53			13	11	81	24	1	30	0	10	72	27	17	5	39	4	1	0	13	22	2
			2	151	21	41	38	64	34	52	13	0	74	3	17	58	70		11	7	87	17	1	28	0	7	76	21	9	1	42	4	2	0	17	25	3
			X	31	100	0	0	67	39	52	10	0	77	0	19	58			10	3	84	26	3	35	0	3	81	23	6	0	45	6	3	0	16	29	0
10	57	Widespread use of computer programs that automatically improve their own functionality through learning - by imitating the functions of living organisms.	1	88	15	24	61	55	20	60	20	0	68	2	45	43			2	11	69	23	0	38	0	18	52	44	14	15	38	3	1	3	7	13	0
			2	77	14	19	66	57	19	69	12	0	73	1	49	32	71		1	9	78	18	0	42	0	14	68	55	6	1	39	1	1	1	8	17	0
			X	11	100	0	0	73	45	55	0	0	82	0	45	45			0	0	82	36	0	73	0	9	73	55	9	0	64	0	0	0	9	0	0

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%)			Importance (index, %)					Expected effect (%)			
					High	Medium	Low	Index	High	Medium	Low	Unnecessary	Socio-economic development	Resolution of global problems	People's needs	Expansion of intellectual resources

Forecasted realization time			Leading countries (%)						Measures the government should adopt (%)							Potential problems (%)			
2001 ▼ 2006 ▼ 2011 ▼ 2016 ▼ 2021 ▼ 2025 ▼	Will not be realized (%)	Do not know (%)	USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax toughness)	Others	Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects

3.3 Künstliche Intelligenz

3	26	Development of equipment for automatic preparation of summaries and abstracts of books and other documents (degree of condensation can be adjusted as necessary).	1	191	20	41	39	63	34	49	17	0	70	6	53	37	72	8	4	76	19	1	47	2	14	56	32	16	15	37	7	2	0	11	19	2
			2	155	15	43	43	60	27	57	16	0	67	2	56	31		7	1	82	14	0	45	1	10	63	28	12	9	37	5	3	0	6	19	2
			X	23	100	0	0	76	52	48	0	0	65	9	61	35		0	9	100	13	0	65	0	0	87	30	9	13	43	13	13	0	4	22	4
3	74	Development of computer program which beats professional Shogi (Japanese Chess) champions.	1	162	7	27	65	28	3	16	68	13	10	0	14	64	73	9	13	35	12	2	66	1	7	31	14	4	1	16	2	3	0	0	14	1
			2	131	8	23	69	28	5	12	69	15	7	1	10	69		13	9	28	8	2	78	0	3	34	9	2	1	11	1	3	0	0	16	0
			X	10	100	0	0	47	33	0	56	11	10	10	10	70		10	10	30	10	0	80	0	0	20	0	0	0	0	10	0	0	0	10	0
10	31	Widespread use of interactive AI systems that help people create ideas by offering useful triggers and contexts.	1	86	6	26	69	48	19	40	40	2	59	3	27	49	74	13	6	73	10	1	26	0	16	49	30	12	9	29	2	1	0	15	17	2
			2	77	5	18	77	46	13	46	41	0	60	3	29	42		9	5	83	9	0	23	0	13	64	35	6	3	32	3	1	0	13	22	0
			X	4	100	0	0	63	50	0	50	0	100	0	25	25		25	0	100	50	0	25	0	0	50	25	25	0	0	0	0	0	0	25	0
10	66	Development of brain support systems that make judgment processes, skills, know-how and experiences of some people accessible to others for reuse or learning purposes.	1	112	12	26	63	60	28	60	12	1	68	1	51	35	75	4	8	62	24	2	37	0	21	52	39	18	10	43	4	1	3	17	29	1
			2	92	10	25	65	56	17	73	10	0	82	1	48	27		5	7	73	17	0	40	0	13	68	39	8	1	49	2	0	2	14	39	0
			X	9	100	0	0	67	33	67	0	0	78	0	67	33		11	0	78	11	0	67	0	0	67	44	11	0	44	11	0	0	33	67	0
3	29	Development of systems capable of recognizing and understanding expressions which use metaphors to express information.	1	168	18	33	49	46	15	43	39	4	40	1	44	38	76	15	11	59	23	1	48	1	21	63	27	10	10	27	1	0	0	2	14	1
			2	133	17	29	54	40	7	45	45	4	41	0	55	38		16	6	71	21	0	54	0	17	67	28	8	4	26	2	2	0	2	14	1
			X	23	100	0	0	40	4	48	48	0	39	0	30	70		17	9	91	13	0	65	0	4	74	30	4	4	26	4	4	0	4	22	0
10	68	Practical use of "behavior alarm" systems based on elucidation of physical and psychological mechanisms that cause human error.	1	88	9	26	65	63	35	48	14	2	47	6	81	18	77	3	5	44	22	1	30	1	33	53	45	13	2	44	8	0	1	27	31	2
			2	78	6	22	72	62	29	64	6	1	47	3	78	8		1	5	50	15	0	32	0	33	63	49	6	0	53	4	0	1	27	35	0
			X	5	100	0	0	65	40	40	20	0	60	0	100	0		0	0	60	40	0	60	0	0	60	20	20	0	100	0	0	0	40	40	0

4 Robotik

4.1 Bau- und Wartungsroboter

4.2 Versorgungs- und Unterstützungsroboter

4.2.1 Roboter im Pflege- und Gesundheitsbereich

4.2.2 Haushaltsroboter

4.3 Roboter für Sicherheit und Katastrophenschutz

4.4 Landwirtschaftsroboter

4.5 Roboter zur Rohstoffgewinnung

4.6 Unbemannte Fahrzeuge

4.7 Allgemeine Thesen zu Intelligenz und Aktorik

4.1 Bau- und Wartungsroboter

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%)			Importance (index, %)					Expected effect (%)				Forecasted realization time							Leading countries (%)						Measures the government should adopt (%)								Potential problems (%)			
					High	Medium	Low	Index	High	Medium	Low	Unnecessary	Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources	2001	2006	2011	2016	2021	2026	Will not be realized (%)	Do not know (%)	USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relaxation)	Others	Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
11	56	Widespread use in Japan of intelligent robots on construction sites to reduce construction period and to ensure safety.	1	198	14	34	53	54	20	55	24	1	75	8	45	6							2	5	28	9	1	72	1	15	34	60	23	2	35	20	3	2	24	11	6
			2	174	13	31	56	53	15	66	18	0	89	2	39	2							1	2	29	5	0	86	1	10	33	72	20	0	36	18	1	0	41	8	3
			X	22	100	0	0	58	18	77	5	0	91	5	50	0							0	0	41	14	0	100	0	0	45	73	36	0	59	14	0	0	27	9	14
10	14	Development of maintenance robots capable of diagnosing and repairing machinery and equipment previously carried out by humans.	1	161	22	32	46	60	31	48	18	3	74	12	49	4							4	7	57	18	0	73	1	10	37	55	18	2	34	11	1	1	28	14	1
			2	137	22	30	48	62	30	57	12	1	82	7	45	4							3	4	62	13	0	82	0	5	36	72	11	1	38	7	0	0	40	10	1
			X	30	100	0	0	70	50	33	13	3	83	3	37	10							7	0	50	20	0	87	0	0	50	67	7	3	43	10	0	0	43	17	3
10	65	Widespread use of robots for work in hazardous or extreme conditions, ensuring worker safety, while bringing about changes in employment opportunities and modes.	1	154	19	23	58	66	40	46	13	1	67	16	77	3							1	5	51	22	0	73	0	15	36	51	22	3	45	22	1	3	18	19	2
			2	127	16	24	60	65	37	52	10	2	74	10	76	1							0	4	52	11	0	79	0	13	34	60	13	0	56	17	0	2	21	20	0
			X	20	100	0	0	71	55	30	5	10	70	5	70	5							0	5	50	5	0	95	0	0	45	45	5	0	50	25	0	0	30	30	0
5	32	Development of fail operational space robot with self-diagnostic capabilities and self-restoration capabilities.	1	220	16	31	53	65	37	50	13	0	79	11	20	25							3	6	87	22	6	60	2	5	63	42	23	1	66	2	0	4	6	5	2
			2	198	14	27	59	62	29	61	10	0	87	7	20	22							2	6	90	21	4	68	1	6	66	38	18	2	75	1	0	3	6	4	1
			X	27	100	0	0	84	70	26	4	0	93	7	15	11							4	0	93	30	4	78	0	4	78	44	19	0	70	0	0	0	4	7	7
12	34	Widespread use of robots that have a tactile sense and work at locations inaccessible to humans via remote control.	1	145	4	19	77	66	38	49	14	0	66	44	55	10							0	5	63	16	3	57	1	17	42	43	23	1	48	2	1	6	16	15	2
			2	123	2	20	77	61	30	57	13	0	68	44	52	6							1	3	76	9	1	65	0	11	43	46	17	1	62	2	1	6	16	11	2
			X	3	100	0	0	67	33	67	0	0	67	67	67	0							0	0	100	0	0	0	0	0	33	33	0	0	33	33	0	0	0	33	0

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Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%)			Importance (index, %)					Expected effect (%)			
					High	Medium	Low	Index	High	Medium	Low	Unnecessary	Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources

Forecasted realization time (2001, 2006, 2011, 2016, 2021, 2026)			Leading countries (%)						Measures the government should adopt (%)							Potential problems (%)			
	Will not be realized (%)	Do not know (%)	USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax toughen)	Others	Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects

4.2 Versorgungs- und Unterstützungsroboter

4.2.1 Roboter im Pflege- und Gesundheitsbereich

57	Practical use of robots to guide blind people in particular districts such as stations and shopping centers.	1	125	[illegible]	24	67	59	28	52	18	2	7	0	98	2	0	6	29	38	0	33	0	34	22	43	11	2	65	26	1	0	26	14	2
3		2	121	7	23	70	58	21	68	11	0	2	0	100	0	0	3	26	50	0	38	0	27	17	50	7	1	80	26	0	0	38	7	2
		X	8	100	0	0	81	63	38	0	0	13	0	100	0	0	0	50	75	0	38	0	0	25	75	25	0	75	50	0	0	25	0	0
54	Practical use of robots which provide medical care support in homes, hospitals, etc.	1	131	10	27	63	75	54	40	5	1	40	2	95	4	4	4	67	26	2	56	0	14	46	46	14	2	60	16	2	0	21	27	2
3		2	111	7	21	72	81	64	30	5	1	42	0	95	3	2	5	76	20	3	66	0	8	46	48	5	0	70	14	0	0	25	29	1
		X	8	100	0	0	82	71	14	14	0	38	0	75	13	0	13	88	13	0	75	0	0	50	13	0	0	75	25	0	0	13	38	0
58	Practical use of intelligent wheel-chairs capable of coping with stairs, escalators, slopes, etc.	1	101	6	18	76	55	23	52	23	2	11	0	95	3	0	5	28	34	0	27	0	39	22	44	12	1	58	23	4	0	32	12	2
3		2	99	3	16	81	54	16	66	18	0	5	0	99	1	0	2	28	44	0	26	0	34	14	45	7	0	77	23	0	0	47	6	1
		X	3	100	0	0	67	33	67	0	0	33	0	100	0	0	0	33	67	0	33	0	0	0	67	0	0	100	0	0	0	0	0	0
90	Widespread use of robots that care for people with severe physical and mental disabilities.	1	71	14	15	70	62	33	49	18	0	49	3	97	13	6	7	58	31	1	55	0	18	51	77	27	4	49	8	1	0	25	38	
		2	57	14	11	75	60	30	50	20	0	47	0	96	12	2	4	68	25	2	68	0	9	61	68	23	0	46	9	0	0	21	39	
		X	8	100	0	0	86	71	29	0	0	75	0	100	25	0	0	50	38	0	75	0	13	63	75	38	0	25	13	0	0	13	38	
46	Widespread use in Japan of houses equipped with robots and other devices that assist senior citizens and disabled people with everyday tasks, including eating meals, bathing, going to the toilet, and having entertainment, to carry these out without human assistance.	1	116	3	16	80	54	21	55	21	3	30	0	96	3	6	7	33	36	1	29	1	29	27	51	17	3	57	22	5	0	31	31	1
11		2	109	3	12	85	56	20	67	12	1	22	0	97	1	5	6	30	49	0	24	0	34	25	61	9	1	67	17	2	0	42	38	0
		X	3	100	0	0	83	67	33	0	0	33	0	100	0	33	0	0	33	0	33	0	67	0	33	33	0	67	0	0	0	0	33	0

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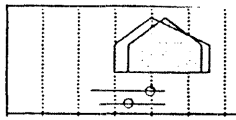
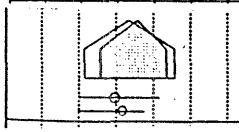
Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%)			Importance (index, %)					Expected effect (%)			
					High	Medium	Low	Index	High	Medium	Low	Unnecessary	Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources

Forecasted realization time (2001, 2006, 2011, 2016, 2021, 2025)			Leading countries (%)						Measures the government should adopt (%)							Potential problems (%)			
	Will not be realized (%)	Do not know (%)	USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax toughen)	Others	Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects

4.2.2 Haushaltsroboter

2	25	Widespread use (one in every household) of "housekeeping robots" capable of cleaning, laundry, etc.	1	199	4	16	80	51	21	43	32	3	45	4	91	3	88		11	9	47	11	2	54	0	27	26	45	13	2	23	6	3	2	13	26	2
			2	197	3	14	83	50	18	49	30	3	41	1	94	1			11	7	50	6	0	66	0	21	30	55	8	1	28	5	4	2	11	30	2
			X	6	100	0	0	79	67	17	17	0	50	0	83	0			0	0	50	0	0	83	0	0	50	50	17	0	33	0	0	0	17	33	0
10	39	Development of home-use-robots that carry out chores such as vacuuming and clothes washing by learning their owners' habits.	1	123	15	24	61	44	15	39	38	8	45	2	89	2	89		11	5	46	8	1	51	1	21	30	37	9	2	22	9	2	1	19	26	1
			2	101	16	22	62	41	10	42	39	8	43	0	90	1			12	1	50	2	0	70	0	16	39	52	2	0	28	5	1	0	22	29	0
			X	16	100	0	0	69	50	31	13	6	50	0	94	6			6	0	56	6	0	88	0	0	50	50	0	0	38	6	0	0	25	31	0

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%)			Importance (index, %)					Expected effect (%)			
					High	Medium	Low	Index	High	Medium	Low	Unnecessary	Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources

Forecasted realization time							Leading countries (%)						Measures the government should adopt (%)							Potential problems (%)			
2001	2006	2011	2016	2021	2026	Will not be realized (%)	Do not know (%)	USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax toughen)	Others	Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture of society	Other adverse effects

4.3 Roboter für Sicherheit und Katastrophenschutz

3	63	Practical use of automatic security surveillance systems using robots equipped with crime prevention functions and information.	1	149	9	30	62	58	25	55	19	1	58	5	84	3			1	5	74	13	2	48	0	13	36	40	10	2	26	22	2	0	47	24	1
			2	121	7	25	68	58	23	64	13	0	60	3	81	2	90		0	2	82	8	0	46	0	7	40	40	7	1	22	25	2	0	54	27	0
			X	9	100	0	0	75	56	33	11	0	78	11	78	11			0	0	67	0	0	67	0	0	22	56	22	0	44	44	11	0	22	22	0
3	49	Practical use of robots capable of recognizing, finding, and rescuing humans involved in a disaster.	1	119	8	26	66	72	48	42	10	0	36	11	86	7			8	7	68	22	3	50	1	16	48	39	18	3	53	9	0	1	25	13	1
			2	94	9	20	71	74	53	38	10	0	31	4	90	3	91		4	6	79	18	3	59	0	12	55	35	11	0	68	4	1	1	29	11	0
			X	8	100	0	0	81	63	38	0	0	63	0	88	13			0	13	88	0	0	75	0	13	63	25	38	0	88	13	0	0	63	25	0

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%)			Importance (index, %)					Expected effect (%)			
					High	Medium	Low	Index	High	Medium	Low	Unnecessary	Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources

Forecasted realization time (2001 ▼ 2006 ▼ 2011 ▼ 2016 ▼ 2021 ▼ 2026 ▼)			Leading countries (%)						Measures the government should adopt (%)							Potential problems (%)			
	Will not be realized (%)	Do not know (%)	USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax toughen)	Others	Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects

4.4 Landwirtschaftsroboter

9	13	Development of biomimic farming machines such as small weeding robots that imitate the motions of the "Kabuto-ebi" shrimp or "Ai-gamo" duck, and pollinating robots mimicking bees.	1	154	14	19	68	50	20	44	30	6	48	54	22	12	92	10	8	33	14	0	45	1	38	43	64	12	1	48	2	0	21	5	10	3
			2	137	10	18	72	47	16	47	31	6	55	58	17	4		9	7	36	9	0	58	0	30	46	72	7	1	45	1	0	19	3	10	1
			X	14	100	0	0	61	36	43	14	7	57	57	14	0		14	0	29	7	0	86	0	14	64	79	7	0	29	0	0	0	14	7	7
	38	Practical use of self-driven planting machines capable of the preparation of large areas of wasteland and the planting of pot seedlings.	1	99	8	22	70	51	20	47	30	3	32	84	13	1	93	5	13	28	24	2	30	2	36	35	55	13	0	46	0	0	34	4	1	4
			2	90	4	21	74	44	7	57	36	0	30	87	10	0		2	7	30	22	1	37	0	37	37	64	9	0	50	1	0	39	2	2	3
			X	4	100	0	0	50	25	25	50	0	50	75	0	0		0	0	25	25	0	100	0	0	25	25	25	0	50	0	0	25	0	0	25
9	14	Development of remote-controlled, multi-purpose agricultural robots with artificial intelligence, that can make even aged people self-reliant in cultivation and harvesting of crops.	1	171	15	18	67	63	37	43	18	2	50	47	54	3	94	6	5	44	17	0	54	1	25	38	71	17	0	51	2	1	9	12	13	4
			2	157	11	17	72	61	33	49	16	2	57	37	58	2		3	4	50	10	0	68	1	19	37	80	8	0	55	3	0	4	12	11	1
			X	18	100	0	0	74	56	33	6	6	67	50	44	6		11	0	44	6	0	83	6	6	61	78	6	0	50	17	0	6	33	0	6
9	12	Practical use of agricultural robots capable of harvesting and simultaneous sorting of fruits according to quality.	1	189	15	23	61	54	22	51	26	1	55	40	28	1	95	3	5	46	21	1	56	0	22	31	70	16	0	40	1	1	10	6	9	5
			2	170	13	23	64	53	20	53	27	1	71	34	25	1		2	3	54	20	0	65	0	16	28	78	12	0	40	1	0	8	5	11	4
			X	22	100	0	0	67	45	36	14	5	77	27	18	0		9	0	59	32	0	77	0	5	55	77	5	0	55	0	0	9	14	5	5

4.5 Roboter zur Rohstoffgewinnung

6	38	Practical use of robots for underwater resource exploration at depths of up to 10,000 m.	1	142	8	20	72	53	20	54	25	2	46	74	5	25	96	3	9	63	35	4	62	0	11	35	51	29	1	62	0	1	17	8	1	3
			2	129	8	18	74	52	14	67	19	1	44	76	0	26		2	5	73	31	2	70	0	9	43	60	23	0	75	1	0	21	4	2	2
			X	10	100	0	0	53	10	80	10	0	30	80	0	0		10	0	60	20	10	90	0	0	40	40	0	0	60	0	0	30	0	0	0
7	18	Practical use of a highly economical unmanned mining technique that combines robot technologies.	1	136	7	12	82	53	20	53	24	2	47	63	22	5	97	2	9	46	23	4	49	3	22	31	47	18	1	43	4	3	32	14	4	1
			2	108	6	12	82	50	13	64	23	0	52	62	16	3		1	7	54	15	0	53	2	21	31	56	11	0	49	6	1	40	9	4	1
			X	6	100	0	0	58	33	33	33	0	67	100	17	0		0	0	83	17	0	100	0	0	17	83	0	0	50	0	0	50	0	0	0

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%)			Importance (index, %)					Expected effect (%)			
					High	Medium	Low	Index	High	Medium	Low	Unnecessary	Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources

Forecasted realization time (2001, 2006, 2011, 2016, 2021, 2026)			Leading countries (%)						Measures the government should adopt (%)								Potential problems (%)			
	Will not be realized (%)	Do not know (%)	USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/tighten)	Others		Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects

4.6 Unbemannte Fahrzeuge

20	Spread of the automatic operation of motor vehicles on expressways etc. via guidance and control to ensure safety, eliminate driver fatigue, increase traffic capacity, etc.	1	163	18	28	54	56	25	51	22	2	53	25	85	6	98		5	5	60	34	1	53	0	22	26	55	21	2	52	39	4	4	42	11	2
		2	156	15	31	53	55	21	58	18	2	51	16	88	4			3	2	69	31	1	62	0	16	19	66	15	0	63	37	1	3	53	8	1
		X	24	100	0	0	75	50	50	0	0	79	42	92	4			0	0	96	58	0	79	0	4	29	58	17	0	92	50	8	4	58	4	4
3	56 Widespread use of automobiles which drive automatically.	1	115	6	17	77	62	35	43	21	1	74	14	83	3	99		10	8	71	36	1	50	0	10	33	41	10	2	43	40	3	4	42	16	0
		2	94	4	16	80	61	33	47	21	0	81	7	86	2			6	4	78	36	1	59	0	6	28	45	6	0	54	56	1	2	62	12	0
		X	4	100	0	0	83	67	33	0	0	100	0	50	0			0	25	100	50	0	25	0	0	25	50	0	0	75	100	0	0	50	50	0
1	Development of intelligent railway vehicles to be able to obtain improved riding comfort and reduce maintenance cost of ground facilities automatically controlling running speed and adjusting suitable parameters to control suspensions in response to track and catenary conditions.	1	121	15	31	54	55	23	50	26	1	50	18	62	5	100		2	2	10	42	0	66	0	18	22	38	21	0	39	21	2	6	17	2	5
		2	118	14	29	58	54	20	56	23	1	53	11	70	2			2	2	8	42	1	72	0	13	19	51	21	0	44	19	2	4	31	1	3
		X	16	100	0	0	72	50	38	13	0	69	13	69	0			0	0	13	63	0	81	0	0	25	44	38	0	56	25	0	0	25	0	0
11	Practical use of unmanned, untethered submersibles for gathering abyssal specimens.	1	205	11	33	57	62	34	48	17	1	29	82	8	39	101		1	6	76	40	4	62	1	9	38	55	27	0	73	1	0	21	8	0	1
		2	174	10	32	58	63	31	61	8	0	22	78	4	47			1	5	79	36	3	68	0	7	35	59	24	0	76	0	1	23	4	1	2
		X	18	100	0	0	82	67	28	6	0	11	78	11	44			6	0	89	33	6	61	0	0	22	61	17	0	83	0	0	17	0	6	11
35	Practical use of autonomous three-dimensional navigation systems for underwater vehicle.	1	79	14	25	61	53	22	50	24	4	70	33	6	25	102		0	3	66	23	8	52	0	15	38	54	15	1	58	3	0	9	16	3	1
		2	70	13	26	61	50	13	61	26	0	79	23	1	20			1	3	74	24	4	57	0	11	41	61	14	0	67	1	0	4	19	1	1
		X	9	100	0	0	53	11	78	11	0	78	44	0	11			0	0	78	11	0	89	0	0	44	67	0	0	56	0	0	0	22	0	0
37	Development of autonomous, unmanned, underwater investigation vessels employing artificial intelligence which are capable of investigating sea-bottom resources and undertaking other activities without receiving any energy supply or external communication.	1	103	22	29	49	50	19	49	29	3	42	56	10	29	103		3	7	51	33	2	61	0	12	50	43	19	0	66	4	1	17	6	1	
		2	91	18	30	53	51	13	63	23	0	43	69	4	27			2	3	59	36	0	75	0	12	56	44	15	1	85	3	1	27	8	1	
		X	16	100	0	0	47	6	69	25	0	38	75	0	38			6	0	75	50	0	75	0	0	69	50	13	0	81	0	0	19	6	0	
36	Development of fully automatic ships which are able to navigate and dock automatically.	1	113	24	27	50	45	13	41	43	3	69	6	34	11	104		14	8	15	25	0	63	1	27	40	42	12	1	49	34	1	4	39	4	
		2	103	20	25	54	45	15	40	42	4	79	4	30	7			14	4	17	24	0	75	0	17	37	48	4	0	58	36	1	5	54	2	
		X	21	100	0	0	60	29	57	10	5	90	5	14	5			14	0	24	38	0	95	0	0	29	62	10	0	71	48	0	5	52	5	
44	Practical use of unmanned planes for typhoon observation and data/sample collection.	1	85	5	19	76	62	33	49	16	1	20	69	45	18	105		7	9	62	12	5	22	4	22	36	38	27	1	66	8	1	13	16	0	2
		2	82	4	18	78	63	32	60	7	1	20	78	41	15			6	9	70	9	0	24	2	18	44	33	23	0	73	2	1	13	21	0	2
		X	3	100	0	0	83	67	33	0	0	0	67	33	0			0	0	100	33	0	33	0	0	33	67	0	0	100	0	0	33	33	0	0

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%)			Importance (index, %)					Expected effect (%)			
					High	Medium	Low	Index	High	Medium	Low	Unnecessary	Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources

Forecasted realization time							Leading countries (%)						Measures the government should adopt (%)							Potential problems (%)			
2001	2006	2011	2016	2021	2026	Will not be realized (%)	Do not know (%)	USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/tighten)	Others	Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects

4.7 Allgemeine Thesen zu Intelligenz und Aktorik

3	34	Development of robots capable of identifying and repairing their own faults by themselves.	1	138	10	33	57	63	34	54	11	1	79	15	44	20	9	9	74	17	5	56	0	14	62	41	14	3	42	3	1	4	9	12	1
			2	111	5	25	69	58	21	70	8	1	86	13	41	13	6	5	80	12	2	63	0	9	68	37	8	2	50	2	1	0	12	14	1
			X	6	100	0	0	54	33	33	17	17	67	33	0	33	17	17	67	0	0	67	0	17	67	33	0	0	83	17	0	0	17	33	0
3	71	Emergence of robots capable of acting as opponents to humans in sports activities (such as Sumo Wrestling, etc.).	1	101	8	20	72	33	6	24	61	9	26	0	69	8	7	11	45	15	1	35	0	24	29	32	14	4	22	3	3	0	13	19	4
			2	83	8	16	76	32	6	16	73	5	18	0	72	8	7	8	52	13	0	36	0	22	27	33	8	2	22	4	2	0	13	28	1
			X	7	100	0	0	46	29	0	71	0	29	0	86	14	14	0	100	14	0	71	0	0	57	29	14	14	57	14	14	0	0	29	0
3	39	Practical use of intelligent robots with visual, auditory, and other types of sensors, capable of judging their environment and making decisions autonomously.	1	161	17	25	58	68	41	47	11	0	76	17	66	27	6	8	78	20	5	57	1	10	59	44	22	2	45	5	1	1	21	28	1
			2	128	16	21	63	68	41	49	10	0	80	13	71	21	6	6	84	12	2	59	0	5	66	41	16	2	54	2	2	0	24	31	0
			X	20	100	0	0	68	42	47	11	0	80	20	80	25	5	5	95	10	0	95	0	5	85	30	20	5	75	5	5	0	20	30	0

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5 Mensch-Maschine-Schnittstelle

5.1 Sprachverarbeitung

5.1.1 Sprachsynthese

5.1.2 Spracherkennung

5.1.3 Multimodale Kommunikation

5.1.4 Sprachübersetzung

5.1.5 Übertragung von Willen in Sprache

5.2 Optische Mustererkennung

5.3 Intelligentes Datenbankmanagement

5.4 Agententechnologien

5.5 Lern-/Wahrnehmungsunterstützende Darstellungsformen

5.6 Pädagogische Methoden

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%)			Importance (index, %)					Expected effect (%)			
					High	Medium	Low	Index	High	Medium	Low	Unnecessary	Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources

Forecasted realization time (2001, 2006, 2011, 2016, 2021, 2026)			Leading countries (%)						Measures the government should adopt (%)								Potential problems (%)			
	Will not be realized (%)	Do not know (%)	USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects

5.1 Sprachverarbeitung

5.1.1 Sprachsyntnese

52	Practical use of high-quality speech synthesizing technologies for automatically turning written information into speech of a quality level nearly equal to that of human speech.	1	179	10	25	65	63	34	49	17	0	61	1	89	8		2	4	56	17	0	80	0	9	45	31	15	7	37	2	2	1	10	25	2
		2	157	9	21	70	60	25	64	11	0	59	1	92	1		1	3	51	13	0	88	0	6	60	27	11	4	41	1	2	1	10	25	1
		X	14	100	0	0	86	71	29	0	0	71	0	100	0		0	0	50	14	0	100	0	0	86	29	0	7	50	7	0	0	7	29	7

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5.1.2 Spracherkennung

2	22 Practical use of single-chip voice recognition integrated circuits which incorporate learning functions capable of identifying different speakers.	1	233	9	22	69	71	45	49	7	0	81	1	78	11		1	8	77	19	0	71	0	12	56	55	18	4	36	2	1	1	18	12	1
		2	217	7	19	74	70	41	56	3	0	79	0	85	8		1	3	81	10	0	76	0	8	62	60	12	1	40	1	0	0	17	7	1
		X	16	100	0	0	91	81	19	0	0	75	6	88	13		0	0	81	19	0	81	0	0	56	63	25	0	44	0	6	0	6	6	6
3	27 Widespread use of voice word processors in which Japanese text can be input by voice (continuous speaking by unspecified speakers)	1	194	14	39	47	59	31	43	26	1	58	1	86	13		10	4	53	14	1	82	1	6	54	37	10	10	41	3	1	0	8	16	0
		2	157	13	36	51	56	25	49	25	0	55	1	87	11		10	3	47	9	0	92	1	3	62	32	7	7	45	2	3	0	4	17	1
		X	21	100	0	0	64	33	57	10	0	43	5	95	10		14	5	67	0	0	100	0	0	52	19	5	10	48	5	10	0	0	19	5
89	Widespread use of portable conversational speech interpretation systems.	1	66	6	20	74	62	37	40	22	2	67	3	70	29		0	6	52	21	0	59	2	15	48	68	30	3	41	5	0	0	11	35	
		2	58	5	17	78	58	26	56	16	2	66	2	78	17		2	2	64	14	0	72	0	7	50	67	24	0	43	2	0	0	14	36	
		X	3	100	0	0	100	100	0	0	0	100	0	33	33		0	0	100	67	0	67	0	0	67	100	67	0	0	0	0	0	0	33	
	55 Become possible for virtual operators with dialogue comprehension capabilities to converse with humans and operate information equipment.	1	177	18	33	50	54	20	54	25	0	58	3	81	8		5	5	79	17	0	50	1	8	52	34	9	3	36	8	3	0	15	16	1
		2	145	18	26	56	52	15	63	23	0	61	1	86	4		6	2	83	13	0	57	0	8	61	34	4	1	48	3	1	0	19	19	0
		X	26	100	0	0	61	27	62	12	0	73	0	85	4		8	0	85	8	0	58	0	4	69	42	0	4	54	8	0	0	27	23	0

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5.1.3 Multimodale Kommunikation

2	55 Widespread use of multi-modal environments that allow the coordinated use of various input media including a keyboard, mouse, and voice and image recognition devices, as a common means of human-computer interface.	1	167	16	25	59	65	40	40	18	1	67	2	83	7		2	5	86	20	0	50	0	5	40	35	13	1	29	4	2	1	5	12	2
		2	142	14	23	63	63	34	51	14	1	62	1	86	3		2	3	86	15	0	53	0	4	52	39	8	1	28	4	4	1	4	13	1
		X	20	100	0	0	83	65	35	0	0	80	5	100	0		5	0	85	20	0	90	0	0	75	50	20	0	50	10	0	0	5	25	5
12	31 Practical use of information media conversion technologies such as a sign language interpretation communication system enabling a hearing-impaired person and a healthy person to communicate with each other at a great distance apart.	1	168	11	21	68	58	27	48	24	0	26	0	98	8		2	2	54	22	0	42	1	29	47	38	21	1	61	3	2	0	13	28	2
		2	146	10	23	68	58	26	55	19	0	22	0	99	4		2	1	60	18	0	47	1	24	54	37	16	1	70	3	2	0	12	27	1
		X	14	100	0	0	86	71	29	0	0	36	0	100	14		0	0	86	21	0	64	0	0	86	36	7	0	64	7	0	0	7	57	7

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Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%)			Importance (index, %)					Expected effect (%)			
					High	Medium	Low	Index	High	Medium	Low	Unnecessary	Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources

Forecasted realization time							Leading countries (%)						Measures the government should adopt (%)							Potential problems (%)			
2001	2006	2011	2016	2021	2026	Will not be realized (%)	Do not know (%)	USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax toughen)	Others	Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects

5.1.4 Sprachübersetzung

10	28	Widespread use of automatic translation machines capable of rendering foreign-language documents into Japanese (or vice-versa) in offices.	1	125	2	16	82	65	39	45	15	1	74	5	46	16	116		1	2	37	10	1	65	1	17	44	39	14	9	29	5	2	1	4	18	2
			2	110	1	15	84	66	38	52	10	0	83	2	56	6			1	2	30	7	1	85	0	11	57	47	9	4	35	3	0	0	3	22	0
			X	1	100	0	0	100	100	0	0	0	0	0	100	0			0	0	0	0	0	100	0	0	0	100	100	0	100	0	0	0	100	100	0
12	38	Development of an automatic Japanese-English, English-Japanese speech translation telephone system comparable to human simultaneous interpretation in service quality.	1	206	10	22	67	77	58	34	7	0	73	10	78	17	117		9	4	42	18	0	81	1	9	53	34	14	6	47	2	1	0	9	26	2
			2	176	9	20	72	81	63	34	3	0	73	8	86	10			9	3	39	13	1	84	1	5	63	34	10	3	57	2	2	0	6	3	1
			X	15	100	0	0	100	100	0	0	0	93	13	93	7			27	7	60	27	0	93	0	0	80	47	13	0	67	7	7	0	0	53	0
3	28	Practical use of portable translation devices (translates simple, common phrases in both directions) using voice input.	1	182	16	35	49	65	36	52	10	1	64	6	80	18	118		5	4	60	25	0	77	1	9	57	40	11	9	38	2	2	0	5	15	1
			2	148	15	32	53	63	31	61	9	0	57	4	86	14			7	1	64	18	0	82	0	7	65	41	7	6	39	1	3	0	3	18	1
			X	22	100	0	0	64	32	59	9	0	59	5	91	18			9	0	73	14	0	100	0	0	82	32	5	14	41	5	9	0	5	14	0
2	33	Development of household TV sets featuring a real-time language translation function.	1	203	11	23	66	59	32	43	24	2	51	9	83	17	119		11	4	43	25	1	68	0	17	49	34	16	5	45	2	1	0	6	29	1
			2	176	10	22	68	60	29	53	17	1	56	5	88	9			9	3	42	22	1	78	0	13	61	34	11	2	52	1	2	0	3	32	1
			X	17	100	0	0	82	65	35	0	0	82	6	94	12			24	0	71	24	0	94	0	0	82	35	18	0	65	6	0	0	0	29	0
10	27	Practical use of pocket-size voice actuated interpreting machines that enable people to communicate even if they do not speak each other's language.	1	113	2	16	82	65	39	43	17	1	58	12	71	15	120		3	2	48	12	0	58	1	22	40	35	17	5	36	9	3	1	7	19	3
			2	103	1	17	83	64	34	53	13	0	63	5	81	9			3	1	48	9	0	72	0	16	57	46	8	2	43	5	2	0	5	27	1
			X	1	100	0	0	100	100	0	0	0	0	0	100	0			0	0	0	0	0	100	0	0	100	100	0	0	0	0	0	0	100	0	0
2	23	Practical use of portable automatic translation systems with a single-chip LSI.	1	236	9	22	69	76	55	39	6	0	84	5	69	9	121		4	5	66	22	0	76	0	11	52	56	22	4	39	1	1	1	7	15	1
			2	224	8	21	71	77	56	41	3	0	84	4	79	5			3	3	68	15	0	82	1	8	55	61	16	2	46	1	0	1	5	15	1
			X	17	100	0	0	97	94	6	0	0	88	12	88	18			6	6	88	41	0	94	0	0	53	59	35	0	71	0	0	0	6	6	6

5.1.5 Übertragung von Willen in Sprache

3	32	Widespread use of portable conversation devices which convert the volition of disabled individuals into speech.	1	133	6	24	70	63	37	41	22	0	25	1	95	8	122		1	10	66	32	0	34	0	20	47	40	14	8	65	5	2	0	11	18	2
			2	113	4	18	78	60	31	48	22	0	22	0	94	7			0	6	73	32	0	43	0	17	57	35	8	4	73	4	3	0	10	18	0
			X	5	100	0	0	75	50	50	0	0	20	0	60	40			0	20	100	40	0	60	0	0	40	20	0	0	60	40	0	0	0	60	0

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%)			Importance (index, %)					Expected effect (%)			
					High	Medium	Low	Index	High	Medium	Low	Unnecessary	Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources
3	14	Practical use of face, voice, and other personal recognition technology in the area of security management.	1	202	17	35	48	68	41	47	11	1	75	2	67	9
			2	163	15	33	52	67	38	57	6	0	78	2	70	6
			X	24	100	0	0	87	74	26	0	0	79	4	79	17
12	51	Widespread use of character recognition technologies which enable a recognition rate with handwritten Chinese character of 99% or more.	1	169	9	27	64	70	45	43	11	0	75	1	76	9
			2	143	8	25	67	72	48	45	7	0	79	1	83	3
			X	11	100	0	0	100	100	0	0	0	100	0	73	0
3	42	Practical use of systems capable of understanding the content of image data, in order to filter out information traveling on a network which may, for example, be unsuitable for children.	1	171	16	32	53	53	22	49	27	2	47	4	65	11
			2	140	13	31	56	51	17	56	24	3	46	3	72	9
			X	18	100	0	0	72	50	39	11	0	67	0	61	6
3	37	Development of technology capable of distinguishing over 10,000 different human beings from images recorded with a video camera.	1	156	16	24	60	54	22	51	25	1	69	8	55	13
			2	127	13	24	62	53	17	60	23	0	77	6	60	8
			X	17	100	0	0	61	31	50	19	0	71	12	76	18
12	32	Practical use of a support system for visually-impaired persons that converts visual images into audible sounds based on image recognition technology.	1	152	10	26	64	54	24	46	29	1	27	0	97	11
			2	136	8	26	66	54	20	58	21	1	22	0	97	7
			X	11	100	0	0	73	45	55	0	0	18	0	100	0

	Forecasted realization time							Leading countries (%)						Measures the government should adopt (%)							Potential problems (%)			
	2001	2006	2011	2016	2021	2025	Will not be realized (%)	Do not know (%)	USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax toughen)	Others	Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
123							2	2	82	22	1	67	0	8	53	35	15	2	35	17	2	0	54	31	1
							2	1	88	17	1	69	1	6	57	30	13	2	36	17	2	1	53	32	0
							4	4	92	29	8	79	0	4	50	33	13	8	33	25	4	0	67	38	0
124							8	5	20	8	0	95	0	2	46	31	12	6	40	4	3	0	11	20	3
							8	2	12	2	0	95	0	1	54	30	8	2	43	3	3	0	8	20	1
							9	0	0	9	0	100	0	0	55	0	9	9	64	9	0	0	0	27	9
125							12	7	70	14	0	30	1	20	44	30	9	6	29	13	1	0	39	47	0
							9	3	84	9	0	39	2	9	52	28	4	2	38	7	1	0	36	52	1
							0	0	94	22	0	61	11	0	56	33	6	6	61	6	0	0	33	61	0
126							7	10	73	21	2	54	1	12	57	31	15	9	37	4	1	0	39	19	1
							6	3	84	16	1	67	0	8	69	28	12	5	43	1	2	0	45	22	0
							6	0	88	12	0	76	0	0	76	12	6	6	53	6	0	0	47	18	0
127							7	11	57	18	0	37	0	29	52	37	20	3	54	1	2	0	7	19	2
							7	4	64	15	0	41	0	24	62	32	18	1	64	1	1	0	4	21	1
							9	0	91	9	0	64	0	0	91	27	18	0	64	18	0	0	0	27	0

5.2 Optische Mustererkennung

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%)			Importance (index, %)					Expected effect (%)			
					High	Medium	Low	Index	High	Medium	Low	Unnecessary	Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources

Forecasted realization time								Leading countries (%)						Measures the government should adopt (%)							Potential problems (%)			
2001	2006	2011	2016	2021	2026	Will not be realized (%)	Do not know (%)	USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax toughen)	Others	Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects

5.3 Intelligentes Datenbankmanagement

10	21	Widespread use of systems capable of automatically indexing printed documents in databases and searching for them through advancements in pattern recognition technology.	1	143	6	29	65	62	33	50	16	1	82	3	50	11	128	1	2	72	13	1	52	1	15	34	46	17	13	24	11	1	0	22	25	2
			2	122	5	27	68	62	29	61	11	0	89	1	61	5		0	2	84	7	0	60	0	7	37	59	11	7	25	9	1	0	19	33	0
			X	6	100	0	0	63	33	50	17	0	83	0	50	17		0	0	67	0	0	67	0	0	33	50	0	17	33	0	0	0	0	0	0
3	30	Practical use of knowledge bases which consolidate their knowledge in a consistent manner through automatic learning.	1	182	20	40	40	61	31	53	15	1	65	3	42	48	129	18	11	79	28	1	40	1	11	67	33	13	10	39	3	0	0	8	18	1
			2	145	18	34	48	58	23	62	14	1	70	1	36	48		13	7	85	26	1	48	0	10	73	30	8	4	43	2	1	0	3	21	0
			X	26	100	0	0	67	40	48	12	0	65	8	27	58		8	4	85	31	4	50	0	4	77	27	8	15	58	8	4	0	0	31	0

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%)			Importance (index, %)					Expected effect (%)			
					High	Medium	Low	Index	High	Medium	Low	Unnecessary	Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources

Forecasted realization time			Leading countries (%)						Measures the government should adopt (%)							Potential problems (%)			
2001 ▼ 2006 ▼ 2011 ▼ 2016 ▼ 2021 ▼ 2026 ▼	Will not be realized (%)	Do not know (%)	USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax toughness)	Others	Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects

5.4 Agententechnologien

2	30	Practical use of information filters that automatically sort large amounts of information and selectively choose only those items needed.	1	177	16	31	54	73	50	43	7	0	77	12	66	19	130	3	4	86	18	1	45	0	7	44	33	15	11	34	12	2	0	36	31	2
			2	155	15	26	59	72	48	46	6	0	78	7	73	9		0	4	93	12	0	53	0	4	54	33	12	7	35	8	2	0	38	30	1
			X	23	100	0	0	78	57	43	0	0	74	17	83	4		0	4	87	13	0	57	0	4	48	30	13	9	43	9	0	0	43	48	0
3	46	Widespread use of systems facilitating on-demand acquisition of multimedia information dispersed on networks around the globe.	1	213	29	38	34	74	52	43	6	0	82	13	69	23	131	1	1	93	25	0	39	0	2	37	35	13	9	29	38	4	0	28	32	2
			2	169	29	37	34	77	56	41	3	0	83	9	69	20		1	1	94	20	1	40	0	2	43	37	7	5	31	44	2	0	29	36	1
			X	49	100	0	0	88	78	20	2	0	82	18	71	27		0	0	98	29	2	63	0	0	47	37	6	2	39	39	6	0	37	39	2
	51	Widespread use of electronic newspapers or electronic museums which can be compiled to match the specific interests of each individual.	1	207	20	37	43	56	22	56	22	0	67	6	78	14	132	0	2	88	22	0	44	0	6	33	32	14	15	25	33	3	0	20	31	1
			2	164	21	34	45	55	19	65	16	0	65	7	85	9		1	1	94	19	0	53	1	2	38	30	11	13	24	41	2	0	18	36	1
			X	35	100	0	0	67	37	57	6	0	71	11	91	9		0	0	100	14	0	77	3	0	43	31	17	14	40	43	0	0	23	46	3
12	49	Practical use of "electronic secretary" terminals featuring an information agent function for schedule management and database access via a network, as well as voice recognition and fuzzy search functions.	1	224	17	24	60	58	27	53	19	2	78	4	71	9	133	3	4	81	16	0	50	0	8	40	28	13	4	26	10	3	0	27	24	3
			2	195	16	19	65	55	20	64	15	2	77	1	75	4		2	2	87	11	0	49	0	5	54	29	8	2	25	8	2	0	22	22	3
			X	31	100	0	0	74	50	47	3	0	77	3	77	6		0	0	87	10	0	65	0	0	65	35	13	0	42	10	6	0	13	35	0
	19	Practical use of a driver support system that receives and recognizes information necessary for motor vehicle travel on normal roads and transmits danger avoidance signals to the on-board control systems of motor vehicles.	1	158	16	28	56	62	33	51	15	1	49	10	88	3	134	2	4	58	46	0	66	0	18	27	54	19	2	47	31	3	4	30	7	3
			2	154	15	27	58	61	29	58	12	1	42	6	92	1		1	3	68	45	0	78	0	10	20	64	15	1	56	34	1	3	44	5	1
			X	23	100	0	0	82	65	30	4	0	52	9	96	0		0	4	91	87	0	96	0	0	52	74	13	0	87	35	9	4	35	0	4

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%)			Importance (index, %)					Expected effect (%)			
					High	Medium	Low	Index	High	Medium	Low	Unnecessary	Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources

Forecasted realization time								Leading countries (%)						Measures the government should adopt (%)							Potential problems (%)			
2001	2006	2011	2016	2021	2026	Will not be realized (%)	Do not know (%)	USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax toughness)	Others	Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects

5.5 Lern-/Wahrnehmungsunterstützende Darstellungsformen

36	Development of visualized systems which facilitate the easy comprehension of very complex cause-effect relationships such as juridical cases.	1	154	13	33	54	53	20	55	22	3	62	5	40	41			1	5	62	23	0	36	0	24	58	36	12	10	35	4	1	0	10	21	0
		2	132	11	28	61	51	15	64	19	2	67	2	39	35			1	5	70	18	0	42	0	19	64	39	9	6	44	2	2	0	9	29	0
		X	14	100	0	0	59	21	71	7	0	86	0	43	57			0	7	93	21	0	79	0	7	71	43	0	7	64	7	7	0	14	36	0

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5.6 Pädagogische Methoden

00	Widespread use of novel educational curriculums through the elucidation of the physiological and psychological mechanisms of independence formation, personality development, etc. in humans.	1	79	1	19	80	69	48	33	18	1	32	1	56	43			9	16	57	33	1	14	0	29	62	30	25	4	47	8	0	0	16	46	3
		2	68	0	25	75	75	55	35	9	0	31	1	60	40			10	10	68	38	0	12	0	25	68	25	16	1	50	6	1	0	9	40	0
		X	0	-	-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

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6 Herkömmliche IT

6.1 Herkömmliche Prozessortechnologien

6.2 Herkömmliche Speichertechnologien

6.1 Herkömmliche Prozessortechnologien

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%)			Importance (index, %)					Expected effect (%)			
					High	Medium	Low	Index	High	Medium	Low	Unnecessary	Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources
3	4	Practical use of computers with computational speed exceeding 10 TFlops.	1	186	18	38	44	71	47	45	8	0	74	34	13	39
			2	151	13	45	42	70	43	51	6	0	82	31	9	34
			X	20	100	0	0	80	65	25	10	0	80	50	5	25
2	5	Practical use of technology which allows mass processing of patterns with minimum line width as low as 10 nanometers.	1	296	25	38	38	87	75	23	2	0	92	10	10	29
			2	267	24	34	42	93	86	13	0	0	96	6	6	22
			X	63	100	0	0	98	95	5	0	0	97	8	5	32
2	19	Development of processor LSIs with 10 GIPS performance and power consumption of 10 miliwatts or less.	1	204	20	30	50	81	64	32	3	0	92	28	23	10
			2	188	17	32	51	87	74	24	1	1	96	25	17	5
			X	32	100	0	0	94	88	13	0	0	100	31	22	13
2	9	Practical use of semiconductor LSIs that operate at a switching speed of 1 ps or less.	1	266	23	38	39	81	65	30	5	0	92	9	15	27
			2	237	22	35	43	87	74	25	1	0	95	3	8	19
			X	52	100	0	0	95	90	10	0	0	100	8	19	21
2	13	Practical use of TIPS (Tera Instruction Per Second) level microprocessors.	1	211	13	29	58	86	73	24	2	0	93	13	19	20
			2	196	12	24	64	89	79	18	3	0	95	8	14	16
			X	23	100	0	0	91	87	4	9	0	96	17	17	22

	Forecasted realization time								Leading countries (%)						Measures the government should adopt (%)							Potential problems (%)			
	2001	2006	2011	2016	2021	2026	Will not be realized (%)	Do not know (%)	USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax toughness)	Others	Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
137							0	5	90	6	0	64	0	2	53	37	21	2	45	5	2	1	9	6	2
							0	1	91	5	0	64	0	0	66	33	17	0	48	2	1	0	8	5	1
							0	0	80	0	0	70	0	0	70	35	15	0	40	5	0	0	5	5	0
138							0	3	76	16	1	90	3	2	47	51	53	1	50	1	0	3	1	4	2
							0	1	75	10	0	92	1	1	47	50	58	1	54	0	0	2	2	1	1
							0	0	79	19	0	97	0	0	52	44	48	2	65	0	0	3	2	0	2
139							5	10	88	14	0	62	0	3	56	44	26	1	45	0	0	3	2	4	2
							3	9	91	8	0	66	1	3	66	46	20	1	54	0	0	2	2	2	2
							3	0	94	16	0	75	0	0	94	44	19	0	72	0	0	3	3	3	3
140							10	9	80	15	1	79	0	6	52	47	38	2	48	2	2	3	2	4	1
							7	4	84	11	0	83	0	3	60	49	37	1	52	1	0	1	0	2	1
							10	0	92	19	0	90	0	0	67	50	29	0	58	0	2	0	0	2	2
141							6	6	89	10	0	46	0	3	52	45	27	1	48	1	1	1	4	4	1
							4	3	93	5	1	48	0	3	66	47	21	1	54	1	1	0	3	4	1
							4	0	96	9	0	57	0	4	78	35	13	4	83	0	0	0	4	9	4

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%)			Importance (index, %)					Expected effect (%)			
					High	Medium	Low	Index	High	Medium	Low	Unnecessary	Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources

Forecasted realization time (2001, 2006, 2011, 2016, 2021, 2026)			Leading countries (%)						Measures the government should adopt (%)							Potential problems (%)			
	Will not be realized (%)	Do not know (%)	USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Foster human resources	Promote exchange among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relaxation)	Others	Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects

6.2 Herkömmliche Speichertechnologien

2	70	Practical use of small read/write optical filing systems with at least 1 tera bite capacity per system.	1	193	17	33	51	72	48	45	7	0	91	5	26	11	142	1	9	73	12	1	79	0	5	50	49	25	1	34	3	1	1	9	7	1
			2	177	15	33	53	78	58	38	4	0	93	3	28	5		1	6	72	8	0	85	0	3	57	55	17	0	34	2	2	0	7	6	1
			X	26	100	0	0	91	85	12	4	0	96	4	23	15		4	0	65	19	0	88	0	0	69	65	8	0	46	4	0	0	15	12	4
1	67	Development of a magnetic memory hard disk capable of recording 1,000 Gbits density per square inch.	1	199	17	22	61	78	58	38	3	1	91	4	18	13	143	7	15	76	12	1	71	0	7	49	48	26	1	37	1	1	1	4	6	2
			2	180	17	24	59	83	67	32	1	1	94	4	17	10		5	9	82	8	0	78	0	2	56	49	22	0	41	0	0	0	2	5	1
			X	30	100	0	0	92	83	17	0	0	100	3	27	10		0	0	90	7	0	83	0	0	70	50	33	0	60	0	0	0	7	10	0
1	6	Practical use of VLSI with as much as 256 Gbits of memory per chip.	1	281	25	37	38	89	79	20	0	1	95	8	16	15	144	3	4	62	4	1	92	16	1	45	50	45	1	52	3	1	2	3	9	1
			2	251	24	35	42	94	88	11	0	1	95	3	10	11		3	1	61	2	0	96	15	0	44	51	48	1	56	2	0	0	2	6	2
			X	59	100	0	0	97	95	3	0	2	98	7	17	14		5	0	64	0	0	97	25	0	44	56	44	0	69	0	0	0	0	5	2
1	68	Practical use of optical memories with recording density of 10^{11} b/cm^2.	1	206	18	32	50	77	57	37	6	0	87	7	24	16	145	7	14	68	17	0	75	0	5	53	48	25	1	43	1	0	0	5	7	1
			2	184	16	33	51	82	66	32	2	0	92	4	26	10		4	13	71	13	0	83	0	3	59	48	21	0	47	0	0	0	2	4	1
			X	30	100	0	0	97	93	7	0	0	97	7	27	20		0	7	77	10	0	93	0	0	63	73	13	0	57	0	0	0	10	10	0
2	8	Practical use of non-volatile, erasable with more than 100 Gbits capacity random access semiconductor memories.	1	272	21	35	44	84	71	26	2	1	92	10	16	15	146	5	5	71	8	0	88	7	2	46	44	37	1	49	2	1	3	2	7	1
			2	244	22	31	47	88	78	20	1	1	93	5	9	10		4	4	72	3	0	89	6	2	48	48	36	1	52	2	0	0	1	5	1
			X	53	100	0	0	94	91	8	0	2	96	9	11	23		8	0	81	2	0	94	11	0	53	53	30	0	60	0	0	0	0	4	2

7 Sonderthemen

7.1 Evolutionäre Strategien in der Biotechnologie
7.2 Molekulare Elektronik
7.3 Multi-Prozessor-Systeme
7.4 Intelligente Netzfunktionen
7.5 Software-Recycling und -Verifikation

Domain	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%)			Importance (index, %)					Expected effect (%)			
					High	Medium	Low	Index	High	Medium	Low	Unnecessary	Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources

Forecasted realization time							Leading countries (%)						Measures the government should adopt (%)							Potential problems (%)			
2001	2006	2011	2016	2021	2026	Will not be realized (%)	Do not know (%)	USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/tighten)	Others	Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects

7.1 Evolutionäre Strategien in der Biotechnologie

4	12	Practical use of technology to alter the functions of biological molecules and cells by means of molecular evalutional engineering techniques.	1	226	22	37	41	63	33	52	15	0	59	47	38	37	5	7	77	31	0	37	0	15	57	38	24	23	49	9	0	30	8	21	1
			2	187	21	33	46	61	29	59	12	0	66	42	35	30	3	3	88	34	0	43	0	7	70	35	18	18	54	6	1	36	7	20	1
			X	39	100	0	0	74	49	49	3	0	74	36	38	36	0	0	97	44	0	56	0	3	79	44	18	18	62	8	0	26	5	13	3

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Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%)			Importance (index, %)					Expected effect (%)			
					High	Medium	Low	Index	High	Medium	Low	Unnecessary	Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources

Forecasted realization time (2001, 2006, 2011, 2016, 2021, 2026)		Leading countries (%)						Measures the government should adopt (%)							Potential problems (%)			
	Will not be realized (%)	Do not know (%)	USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax toughen)	Others	Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects

7.2 Molekulare Elektronik

2	1	Development of technology capable of manipulating single atoms and single molecules.	1	290	12	38	50	71	48	42	10	0	62	6	7	75	1	4	85	26	0	63	0	9	60	40	45	5	53	1	1	8	2	8	2
			2	258	12	34	54	71	46	46	7	0	62	2	1	79	1	3	92	22	0	69	0	3	64	36	47	2	55	0	0	5	2	6	2
			X	30	100	0	0	91	83	13	3	0	67	3	0	93	0	3	100	37	0	77	0	0	80	47	47	0	63	0	0	0	0	0	0
2	12	Development of atomic-scale, high-speed, highly-integrated devices switching by the movement of a single atom, such as to atom relay transistors.	1	224	9	29	63	64	38	42	17	2	67	7	5	58	16	13	72	27	2	49	0	16	57	39	34	1	43	0	0	1	1	2	3
			2	204	8	25	67	63	35	47	16	1	73	3	3	62	15	12	80	23	0	53	0	13	66	41	32	1	46	0	0	0	0	1	1
			X	17	100	0	0	85	71	29	0	0	88	0	0	65	12	6	88	35	0	76	0	6	71	59	18	0	59	0	0	0	0	0	0
2	51	Development of logic LSIs and memory LSIs in which the basic switching element is a single molecule.	1	184	11	22	67	63	37	41	19	3	76	9	10	54	16	16	67	32	3	40	0	22	61	36	28	5	46	0	1	1	2	6	2
			2	166	11	16	72	61	31	51	18	0	80	4	7	40	13	13	75	27	2	46	0	16	68	37	17	2	54	0	1	0	1	4	1
			X	19	100	0	0	91	84	11	5	0	84	0	11	68	5	5	79	53	11	79	0	5	89	63	5	5	74	0	5	0	0	0	5
2	66	Development of a strage system in which one atom or molecule corresponds to 1 bit.	1	235	17	26	57	72	51	35	12	2	83	7	12	46	12	15	69	26	3	50	0	17	57	36	31	1	50	0	1	1	3	4	2
			2	210	15	25	60	76	57	34	8	1	88	5	9	47	12	12	76	24	1	59	0	13	67	35	25	0	60	0	0	0	1	2	1
			X	32	100	0	0	86	72	28	0	0	97	0	16	59	6	3	94	19	3	69	0	0	78	47	31	0	59	0	0	0	6	6	3

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Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%)			Importance (index, %)					Expected effect (%)			
					High	Medium	Low	Index	High	Medium	Low	Unnecessary	Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources

Forecasted realization time								Leading countries (%)						Measures the government should adopt (%)								Potential problems (%)			
2001	2006	2011	2016	2021	2026	Will not be realized (%)	Do not know (%)	USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relaxing/ease)	Others	Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects

7.3 Multi-Prozessor-Systeme

3	3	Practical use of parallel computers with one million or more processors.	1	197	18	45	37	63	35	47	16	1	68	33	11	50	152		7	6	93	10	1	53	1	3	53	46	20	2	43	4	3	2	6	7	2
			2	160	14	49	37	64	34	54	12	0	79	27	6	42			7	3	96	7	0	55	0	1	63	44	18	0	45	2	2	1	4	6	1
			X	22	100	0	0	68	45	36	18	0	77	36	0	27			5	5	91	5	0	73	0	0	59	59	18	0	36	0	0	0	5	5	0
3	43	Development of super-parallelizing compilers which efficiently execute the applications operated on super-parallel computer systems.	1	163	16	38	46	62	32	54	13	1	75	17	12	37	153		5	7	90	20	1	43	1	5	64	33	27	2	47	2	1	0	1	8	1
			2	141	14	40	46	61	28	59	12	1	80	11	7	33			5	3	94	16	0	46	0	1	72	28	18	1	52	1	1	1	1	7	0
			X	20	100	0	0	63	37	47	11	5	65	10	5	45			0	0	90	0	0	55	0	0	65	15	20	0	40	10	0	0	0	10	0
2	20	Practical use of multi-processor systems with advanced self-restoration capabilities.	1	190	12	26	62	72	46	48	6	0	89	6	24	19	154		3	8	86	21	2	36	0	8	63	47	23	2	42	0	1	2	3	6	2
			2	179	9	23	68	71	44	53	3	0	94	2	22	12			2	6	92	16	2	40	0	6	71	55	16	1	44	0	0	1	2	3	1
			X	17	100	0	0	88	76	24	0	0	94	6	12	18			0	0	94	29	0	76	0	0	88	53	6	0	76	0	0	6	6	6	6

7.4 Intelligente Netzfunktionen

3	25	Practical use of OS capable of operating, in distributed environment on an area network, without cognizance of position as if the systems were a single system.	1	192	27	39	34	69	42	48	9	0	88	8	39	20	155		2	3	95	14	0	28	0	2	58	36	18	1	40	8	2	0	20	12	1
			2	159	25	38	38	67	36	60	4	0	91	6	38	14			2	1	94	11	0	26	0	1	67	30	13	2	43	6	1	0	20	12	0
			X	39	100	0	0	76	54	41	5	0	87	10	44	26			5	3	92	21	0	41	0	0	74	31	15	3	51	3	3	0	18	15	0
3	16	Practical use of administration systems which conduct network connection and operation automatically and without a network administrator.	1	206	26	37	36	70	45	45	11	0	89	5	40	9	156		8	5	92	20	0	36	0	2	49	32	14	2	27	18	1	0	30	16	1
			2	172	24	31	45	73	49	45	7	0	95	2	40	4			7	3	92	15	0	37	0	2	60	29	8	1	23	15	1	0	37	16	0
			X	42	100	0	0	83	66	34	0	0	95	5	52	5			5	2	98	19	0	48	0	0	62	36	12	0	38	19	2	0	33	14	0
3	23	Development of technology capable of automatically detecting viruses and automatically producing corresponding vaccines.	1	157	11	31	58	69	45	44	9	2	69	6	53	10	157		24	19	85	17	3	20	0	8	55	31	9	3	31	7	2	0	31	13	0
			2	125	10	25	65	72	47	48	5	1	78	5	54	7			19	15	91	17	2	22	0	4	63	24	2	2	30	4	2	0	36	12	0
			X	13	100	0	0	73	58	25	8	8	54	8	62	15			23	8	85	15	15	15	0	0	54	15	8	15	31	15	0	0	46	31	0

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%)			Importance (index, %)					Expected effect (%)			
					High	Medium	Low	Index	High	Medium	Low	Unnecessary	Socio-economic development	Resolution of global problems	People's needs	Expansion of intellectual resources

Forecasted realization time								Leading countries (%)					Measures the government should adopt (%)							Potential problems (%)			
2001	2006	2011	2016	2021	2026	Will not be realized (%)	Do not know (%)	USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax toughen)	Others	Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects

7.5 Software-Recycling und -Verifikation

3	44	Separation of developed software into components, and widespread use of software libraries which facilitate the re-utilization of those components.	1	195	27	39	34	79	61	32	6	1	90	7	19	23	150			2	4	90	26	1	43	1	4	57	40	14	12	34	10	3	0	8	11	2
			2	157	27	38	34	81	63	34	3	0	92	4	17	22				1	1	93	20	1	46	0	1	62	45	6	10	34	7	3	0	5	10	1
			X	43	100	0	0	86	74	24	2	0	88	5	16	23				0	2	86	23	0	53	0	2	65	44	7	5	44	7	2	0	5	9	2
3	45	Advances in software inspection and verification technology, enabling quick development of error-free, large-scale software.	1	187	26	41	33	78	61	31	9	0	83	9	17	24	159			21	8	80	26	2	34	0	9	63	29	14	5	39	2	2	0	6	7	2
			2	148	22	43	35	83	68	28	3	0	90	5	12	18				22	3	89	21	1	34	0	5	67	26	9	3	41	3	1	0	5	6	1
			X	33	100	0	0	86	75	19	6	0	79	9	6	21				24	3	88	36	3	48	0	3	67	30	9	0	36	3	3	0	3	9	3

Anhang B: Werte der Delphi-Befragung

In nachfolgender Tabelle sind die Werte der Realisierungszeitpunkte (erstes Quartil, Median, letztes Quartil), des *importance index* sowie der Wirkung auf *socioeconomic development* aufgeführt.

Die Zuordnung der Thesen zu Themengebieten entspricht der in der Detailanalyse einzelner FuE-Gebiete vorgenommenen[1].

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1 Bei der Berechnung des durchschnittlichen *importance-index* pro FuE-Gebiet wurde in wenigen Fällen Thesen nicht berücksichtigt, wenn sie durch ihren Kontextbezug aus dem Rahmen fielen und dadurch in ihrer Bewertung von allen anderen Thesen des gleichen FuE-Gebietes signifikant abwichen. Die Werte dieser Thesen sind in der Tabelle kursiv wiedergegeben.

Nr.	erstes Quartil	Median	letztes Quartil	*importance index*	*effect on socioecon. dev.*
1 Bio-/Humanwissenschaftliche Grundlagenforschung					
1.1 Meß- und Untersuchungsmethoden					
1	2006	2011	2014	65	21
1.2 Molekulare Prozesse					
1.2.1 Allgemeine Thesen zu molekularen Prozessen					
2	2011	2015	2021	54	3
3	2009	2015	2019	61	8
4	2012	2017	2023	65	10
5	2012	2016	2022	49	11
6	2010	2015	2020	63	23
7	2011	2015	2021	50	8
1.2.2 Immunsystem					
8	2009	2013	2017	70	8
9	2012	2017	2021	78	13
1.2.3 Nervensystem					
10	2011	2018	2023	64	9
11	2011	2015	2019	65	54
12	2013	2018	2023	63	8
1.3 Komplexe kognitive Prozesse					
13	2010	2017	2022	68	10
14	2013	2017	2023	48	7
15	2011	2018	>2025	65	33
16	2016	2021	>2025	57	6
17	2015	2023	>2025	71	47
18	2016	2022	>2025	67	15
1.4 Entstehung von Leben					
19	2020	2024	>2025	50	4
1.5 Evolution und Phylogenese					
20	2011	2018	2024	45	1
21	2015	2022	>2025	47	4
1.6 Ontogenese					
22	2017	2022	>2025	71	10
2 Hybride Systeme					
2.1 Hybride Hardware					
2.1.1 Allgemeine Thesen zu "Biocomputern"					
23	2012	2016	2023	60	54
24	2011	2016	2021	61	78
2.1.2 Hybride Hardware auf molekularer Ebene					
25	2010	2015	2020	64	80
26	2014	2018	2024	55	70

Nr.	erstes Quartil	Median	letztes Quartil	*importance index*	*effect on socioecon. dev.*
2.1.3 Hybride Hardware auf zellulärer Ebene					
2.1.3.1 Chip/Zell-Interface					
27	2009	2012	2017	55	39
28	2014	2020	2025	61	47
2.1.3.2 Künstliche Nervensysteme					
29	2016	2020	2025	64	64
30	2013	2018	>2025	55	55
2.1.4 Hybride Hardware auf Organ-/Organismus-Ebene					
31	2012	2019	>2025	67	34
32	2017	2025	>2025	63	69
33	2019	2023	>2025	64	59
34	2022	>2025	>2025	55	33
2.2 Biomolekulare Speicher					
35	2012	2015	2022	82	88
2.3 Biosensorik					
36	2002	2007	2012	65	43
37	2007	2010	2014	68	52
38	7200	2011	2017	45	42
39	2013	2018	2023	56	61
2.4 Implantate/künstliche Organe					
2.4.1 Mikromaschinen					
40	2008	2012	2016	68	80
41	2011	2014	2022	69	47
42	2011	2016	2022	59	76
43	2013	2017	2023	69	47
44	2011	2014	2018	54	44
2.4.2 Künstliche Bewegung von Gliedmaßen/Muskeln					
45	2009	2014	2024	55	42
46	2007	2010	2017	51	35
2.4.3 Künstliche innere Organe					
47	2011	2015	2020	78	35
48	2010	2013	2018	64	19
49	2007	2012	2021	60	49
50	2014	2019	2023	74	22
51	2013	2019	>2025	49	36
52	2009	2014	2023	57	49
53	2009	2015	2020	66	43
54	2011	2016	2022	61	48
55	2007	2010	2014	54	31
56	2013	2019	2024	61	37

Nr.	erstes Quartil	Median	letztes Quartil	*importance index*	*effect on socioecon. dev.*
57	2008	2013	2019	65	48
58	2009	2013	2017	83	20
59	2012	2017	2024	63	45
3 Bioanaloge Basistechnologien					
3.1 Bioanaloge Hardware					
3.1.1 Allgemeine Thesen zu Selbstorganisations-/Regenerations-/Reprod.fähigkeit					
60	2008	2011	2014	73	69
61	2013	2016	2021	65	66
62	2015	2022	>2026	62	83
63	2015	2021	>2026	51	65
64	2017	2022	>2026	61	75
3.1.2 Analogie zu zellulären Prozessen					
65	2011	2016	2022	61	31
3.1.3 Neural Computers					
66	2012	2017	2023	74	85
67	2012	2017	2021	64	90
68	2013	2018	2025	63	81
3.1.4 Automatisches Chipdesign					
69	2009	2014	2018	76	95
3.2 Anpassungsfähige Software					
70	2007	2011	2017	64	74
71	2011	2014	2018	57	73
3.3 Künstliche Intelligenz					
72	2005	2009	2013	60	67
73	*2007*	*2013*	*2018*	*28*	*7*
74	2009	2013	2018	46	60
75	2009	2013	2018	56	82
76	2009	2014	2022	40	41
77	2011	2014	2018	62	47
4 Robotik					
4.1 Bau- und Wartungsroboter					
78	2007	2011	2017	53	89
79	2007	2009	2013	62	82
80	2008	2011	2015	65	74
81	2009	2014	2019	62	87
82	2008	2010	2015	61	68
4.2 Versorgungs- und Unterstützungsroboter					
4.2.1 Roboter im Pflege-/Gesundheitsbereich					
83	2003	2006	2009	58	2
84	2006	2010	2014	81	42

Nr.	erstes Quartil	Median	letztes Quartil	*importance index*	*effect on socioecon. dev.*
85	2005	2008	2012	54	5
86	2007	2012	2017	60	47
87	2009	2014	2019	56	22
4.2.2 Haushaltsroboter					
88	2013	2018	2023	50	41
89	2009	2014	2018	41	43
4.3 Roboter für Sicherheit und Katastrophenschutz					
90	2006	2009	2013	58	60
91	2011	2015	2019	74	31
4.4 Landwirtschaftsroboter					
92	2008	2012	2016	47	55
93	2007	2011	2017	44	30
94	2007	2011	2015	61	57
95	2004	2007	2010	53	71
4.5 Roboter zur Rohstoffgewinnung					
96	2008	2011	2015	52	44
97	2008	2012	2017	50	52
4.6 Unbemannte Fahrzeuge					
98	2011	2015	2019	55	51
99	2013	2017	2022	61	81
100	2003	2006	2009	54	53
101	2004	2007	2012	63	22
102	2005	2008	2013	50	79
103	2005	2009	2014	51	43
104	2010	2014	2019	45	79
105	2008	2011	2017	63	20
4.7 Allgemeine Thesen zu Intelligenz und Aktorik					
106	2012	2016	2019	58	86
107	2008	2014	2019	32	18
108	2009	2014	2021	68	80
5 Mensch-Maschine-Schnittstelle					
5.1 Sprachverarbeitung					
5.1.1 Sprachsynthese					
109	2004	2007	2010	60	59
5.1.2 Spracherkennung					
110	2007	2011	2015	70	79
111	2007	2011	2015	56	55
112	2007	2010	2014	58	66
113	2006	2010	2015	52	61
5.1.3 Multimodale Kommunikation					

Nr.	erstes Quartil	Median	letztes Quartil	*importance index*	*effect on socioecon. dev.*
114	2006	2009	2012	63	62
115	2006	2009	2013	58	22
5.1.4 Sprachübersetzung					
116	2005	2009	2013	66	83
117	2008	2012	2018	81	73
118	2008	2012	2016	63	57
119	2009	2013	2018	60	56
120	2008	2012	2017	64	63
121	2009	2013	2018	77	84
5.1.5 Übertragung von Willen in Sprache					
122	2007	2011	2014	60	22
5.2 Optische Mustererkennung					
123	2002	2005	2008	67	78
124	2004	2007	2011	72	79
125	2007	2010	2015	51	46
126	2008	2012	2018	53	77
127	2011	2013	2017	54	22
5.3 Intelligentes Datenbankmanagement					
128	2003	2006	2009	62	89
129	2011	2014	2019	58	70
5.4 Agententechnologien					
130	2002	2005	2009	72	78
131	2002	2005	2008	77	83
132	2003	2007	2011	55	65
133	2003	2007	2010	55	77
134	2005	2008	2011	61	42
5.5 Lern-/Wahrnehmungsunterstützende Darstellungsformen					
135	2007	2011	2014	51	67
5.6 Pädagogische Methoden					
136	2010	2016	2023	75	31
6 Herkömmliche IT					
6.1 Herkömmliche Prozessortechnologien					
137	2005	2008	2012	70	82
138	2009	2013	2017	93	96
139	2011	2014	2019	87	96
140	2011	2015	2019	87	95
141	2014	2018	2023	89	95
6.2 Herkömmliche Speichertechnologien					
142	2007	2012	2017	78	93
143	2012	2017	2022	83	94

Nr.	erstes Quartil	Median	letztes Quartil	*importance index*	*effect on socioecon. dev.*
144	2011	2014	2019	94	95
145	2013	2016	2021	82	92
146	2012	2017	2022	88	93
7 Sonderthemen					
7.1 Evolutionäre Strategien in der Biotechnologie					
147	2008	2012	2017	61	66
7.2 Molekulare Elektronik					
148	2003	2007	2011	71	62
149	2013	2018	2024	63	73
150	2016	2021	2025	61	80
151	2016	2022	>2026	76	88
7.3 Multi-Prozessor-Systeme					
152	2007	2009	2013	64	79
153	2007	2010	2014	61	80
154	2012	2016	2020	71	94
7.4 Intelligente Netzfunktionen					
155	2003	2006	2010	67	91
156	2004	2007	2011	73	95
157	2006	2009	2013	72	78
7.5 Software-Recycling und -Verifikation					
158	2003	2006	2010	81	92
159	2008	2012	2017	83	90