Exploring how Feature Granularity and Data-Flow Complexity Affect Code Comprehension

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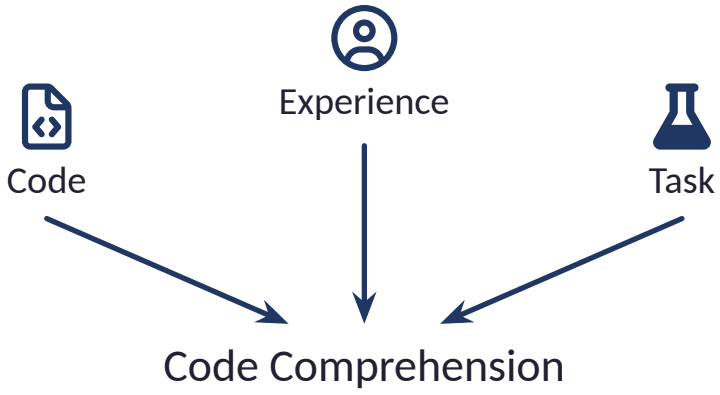
Version A

```
void bubble_sort(int array[], int size) {
  for (int i = 0; i < size - 1; i++) {
    for (int j = 0; j < size - i - 1; j++) {
      if (array[j] > array[j + 1]) {
        int temporary = array[j];
        array[j] = array[j + 1];
        array[j + 1] = temporary;
      }
    }
  }
}
```

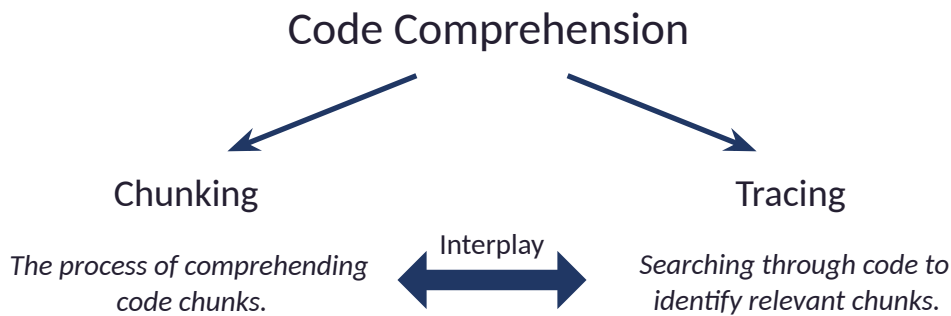
Version B

```
void process(int* arr, int s) {
  int x, y, k;
  for (x = 1; x < s; x++) {
    int val = arr[x]; y = x;
    while (y > 0) {
      if (arr[y - 1] <= val) break;
        arr[y] = arr[y---1];
    }
    arr[y] = val;
  }
}
```

What Makes Code Hard to Understand?



Cognitive Complexity Model (CCM)

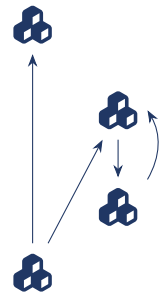


CCM Example

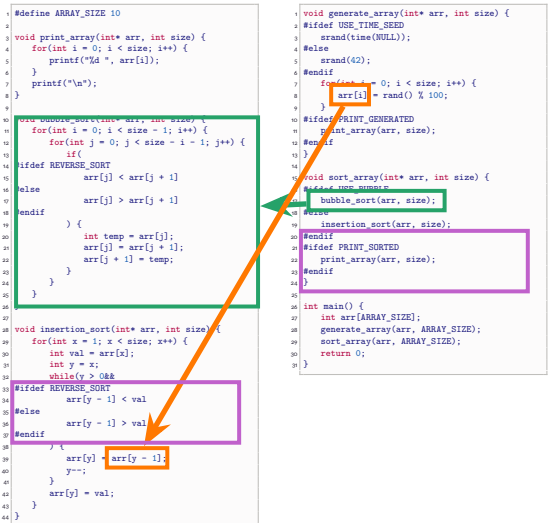
Understanding

```
1  void process(int* arr, int s) {
2    int x, y, k;
3    for (x = 1; x < s; x++) {
4      int val = arr[x]; y = x;
5      while (y > 0) {
6        if (arr[y - 1] <= val) break;
7          arr[y] = arr[y---1];
8      }
9      arr[y] = val;
10   }
11 }
```

Debugging



A Matter of Scale



```c
#define ARRAY_SIZE 10

void print_array(int* arr, int size) {
    for(int i = 0; i < size; i++) {
        printf("%d ", arr[i]);
    }
    printf("\n");
}

void bubble_sort(int* arr, int size) {
    for(int i = 0; i < size - 1; i++) {
        for(int j = 0; j < size - i - 1; j++) {
            if(
#ifdef REVERSE_SORT
                arr[j] < arr[j + 1]
#else
                arr[j] > arr[j + 1]
#endif
            ) {
                int temp = arr[j];
                arr[j] = arr[j + 1];
                arr[j + 1] = temp;
            }
        }
    }
}

void insertion_sort(int* arr, int size) {
    for(int x = 1; x < size; x++) {
        int val = arr[x];
        int y = x;
        while(y > 0&&
#ifdef REVERSE_SORT
            arr[y - 1] < val
#else
            arr[y - 1] > val
#endif
        ) {
            arr[y] = arr[y - 1];
            y--;
        }
        arr[y] = val;
    }
}
```

```c
void generate_array(int* arr, int size) {
#ifdef USE_TIME_SEED
    srand(time(NULL));
#else
    srand(42);
#endif
    for(int i = 0; i < size; i++) {
        arr[i] = rand() % 100;
    }
#ifdef PRINT_GENERATED
    print_array(arr, size);
#endif
}

void sort_array(int* arr, int size) {
#ifdef USE_BUBBLE
    bubble_sort(arr, size);
#else
    insertion_sort(arr, size);
#endif
#ifdef PRINT_SORTED
    print_array(arr, size);
#endif
}

int main() {
    int arr[ARRAY_SIZE];
    generate_array(arr, ARRAY_SIZE);
    sort_array(arr, ARRAY_SIZE);
    return 0;
}
```

Functions and function calls

Complex data dependencies

Feature code

Make tracing more difficult!

Research Gap and Goal

Code Comprehension

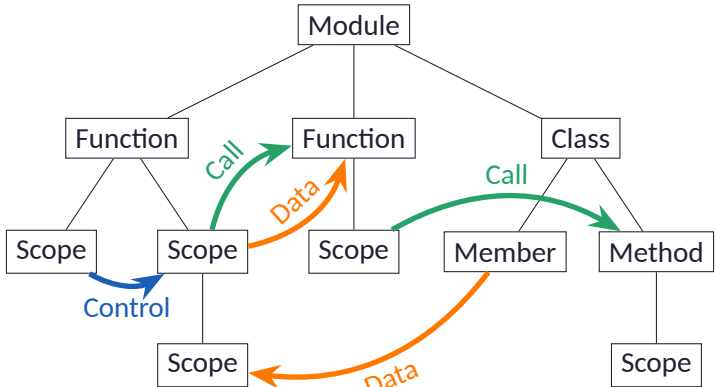
- Many insights into cognitive processes
- Small code snippets
- Local effects

Complexity Metrics

- Widely used
- Structural & syntactic properties
- Lack empirical evidence

Which code structures impact code comprehension and how?

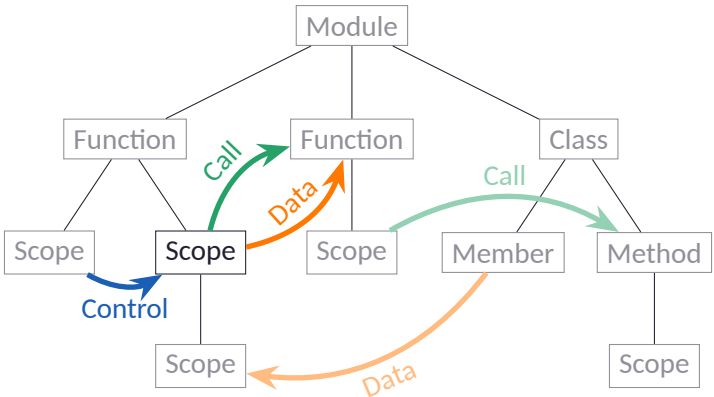
Hierarchical Model of Code



Structures in Code

Structures

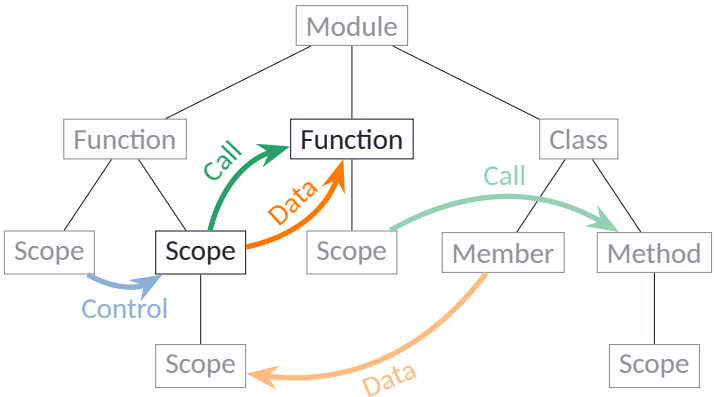
- Amount of dependencies



Structures in Code

Structures

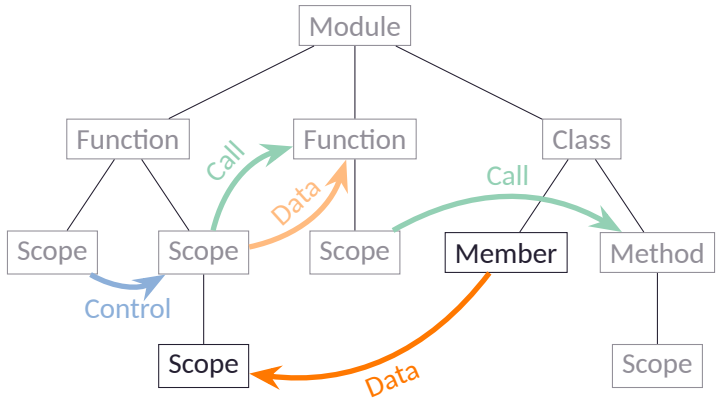
- Amount of dependencies
- Dependency alignment



Structures in Code

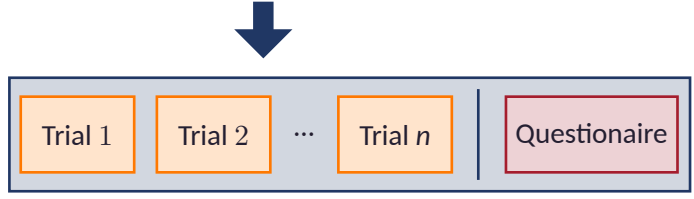
Structures

- Amount of dependencies
- Dependency alignment
- Cross-hierarchy dependencies
- …



Controlled Experiment

Stimuli with code structures + Tracing-focused task



Feature Granularity

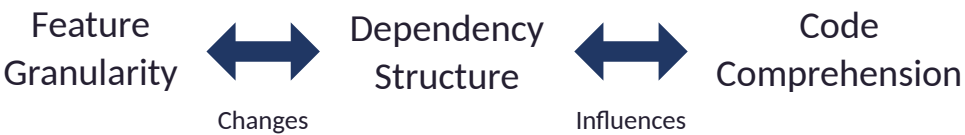
Expression Level

```
1 static int twl_probe() {
2   int *ops =
3 #ifdef CONFIG_OF_IRQ
4     &irq_domain_ops;
5 #else
6     NULL;
7 #endif
8   irq_domain_add(ops);
9 }
```

Function Level

```
1  #ifdef CONFIG_OF_IRQ
2  static int twl_probe() {
3    int *ops = &irq_domain_ops;
4    irq_domain_add(ops);
5  }
6  #else
7  static int twl_probe() {
8    int *ops = NULL;
9    irq_domain_add(ops);
10 }
11 #endif
```

Feature Granularity and Code Comprehension



Which aspects of feature code would you consider?

Cognitive Complexity Model (CCM)

Code Comprehension

Chunking

The process of comprehending code chunks.

Interplay

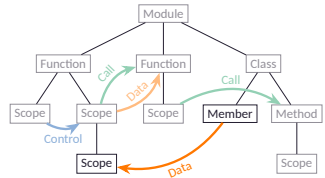
Tracing

Searching through code to identify relevant chunks.

Structures in Code

Structures

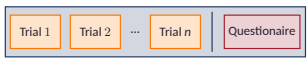
- Amount of dependencies
- Dependency alignment
- Cross-hierarchy dependencies
- …



Controlled Experiment

Stimuli with code structures + Tracing-focused task

Online Study:



Evaluation:

Answer time/correctness → Model of pattern influence

User feedback → Qualitative insights

Feature Granularity and Code Comprehension

Feature Granularity ↔ (Changes) Dependency Structure ↔ (Influences) Code Comprehension

Which aspects of feature code would you consider?

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